# MACHINERY'S DATA SHEETS

REVISED AND RE-ARRANGED IN LIBRARY FORM

No. 14

# Locomotive and Railway Data

PRICE 25 CENTS

CONTENTS





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COMPILED FROM MACHINERY'S MONTHLY DATA
SHEETS AND ARRANGED WITH
EXPLANATORY NOTES

# No. 14

# Locomotive and Railway Data

CONTENTS

In the following pages are compiled a number of diagrams and concise tables relating to locomotives and railway work, carefully selected from MACHINERY'S monthly Data Sheets, issued as supplements to the Engineering and Railway editions of MACHINERY since September, 1898. In order to enhance the value of the tables and diagrams, brief explanatory notes have been provided. In a note at the foot of the tables, reference is made to the page on which the explanatory note relating to the table appears.

# LOCOMOTIVE AND RAILWAY DATA

### Locomotive Boilers

On pages 4 and 5 are shown diagrammatical sketches of eight types of locomotive boilers, indicating, in a general way, the main features of construction. On pages 6 and 7 tables are given for determining at a glance the heating surface of locomotive boiler flues in square feet when the outside diameter and the length in feet and inches are given. Assume that it is required to find the heating surface in square feet of a flue 2 inches in diameter and 8 feet 3 11/16 inches long. From the table on page 6 we find that the heating surface of a flue of this size, 8 feet long, is 4.188 square feet. From page 7 we find that three inches of additional length adds 0.131 square foot, and 11/16 of additional length, 0.030 square foot. The total heating surface then is 4.188 + 0.131 + 0.030 = 4.349.

### Bearing Pressure for Locomotive Journals

On pages 8 to 11, inclusive, are given tables of allowable bearing pressures for the different journals of various classes of locomotives. The figures on page 8 are for the engine truck journals of passenger locomotives, and are based on a pressure of 160 pounds per square inch of projected area. On page 9 are given the safe bearing pressures for the driving and trailing journals of passenger locomotives, based on a pressure of 180 pounds per square inch of projected area. The journals for freight and switching locomotives may be subjected to a pressure of 200 pounds per square inch of projected area, and the total safe allowance for journals of various sizes for locomotives of this class is tabulated on page 10. Page 11 gives the figures for tender journals, these figures being based on a pressure of 300 pounds per square inch of projected area. As an example, assume that it is required to find what would be the safe allowable total pressure on the driving wheel journals of a passenger locomotive, the diameter of the journal being 8 inches and the length 10 inches. From the table on page 9 we find, by locating the diameter in the left-hand column and the length of the journal at the top of the table, that the safe pressure per journal is 14,400 pounds.

### Locomotive Classification

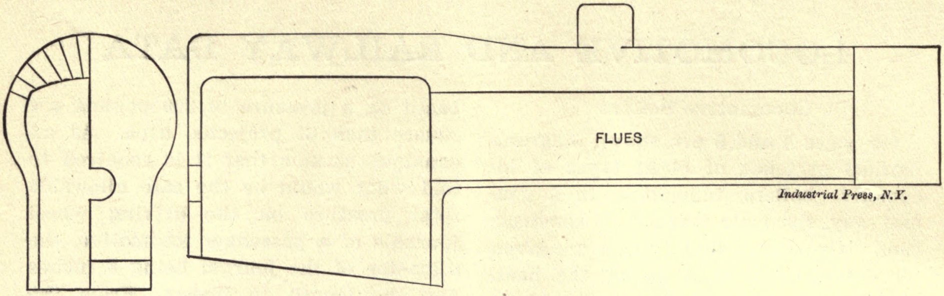
Several different systems are in use for indicating various classes of locomotives, the various methods used being shown on page 12. In America it is quite common to refer to the various types by the names, while in Europe the usual method is to use the Whyte system, in which the number of wheels in the pony truck, the number of driving wheels and the number of wheels in the trailing truck are indicated with figures as shown in the next last column on page 12. According to this system a 4-6-2 locomotive indicates a Pacific type passenger locomotive having a four-wheeled pony truck, six driving wheels and a two-wheeled trailing truck.

### Gages of Principal Railroads of the World

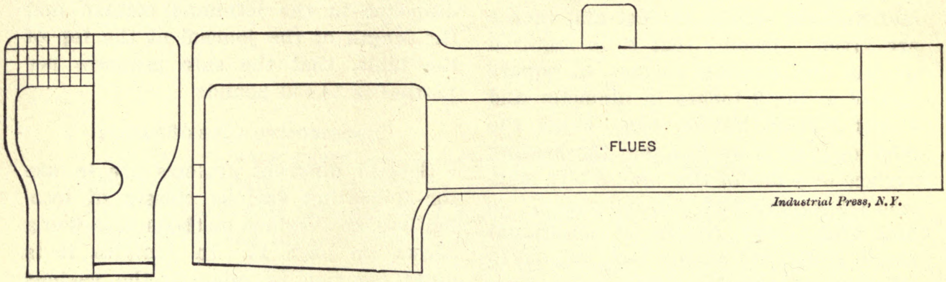
On page 13 a table is given of the gages in use in various countries. The 4-foot 8 1/2-inch standard gage, it will be seen, is used practically everywhere in the leading countries, but some large systems, including that of Russia, which has a 5-foot gage, and that of India, which has a 5½-foot and a meter

(Continued on page 16.)

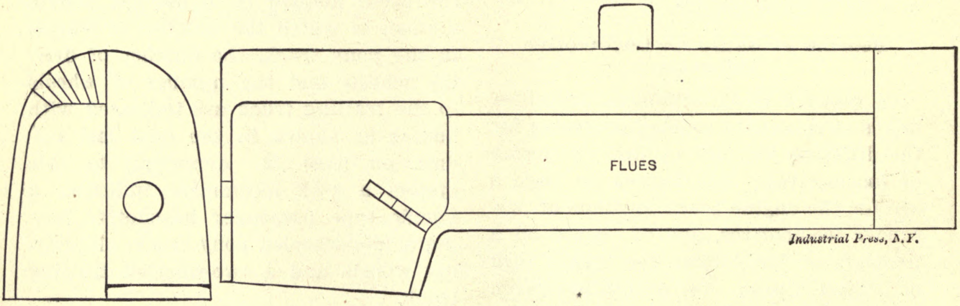
## TYPES OF LOCOMOTIVE BOILERS—I



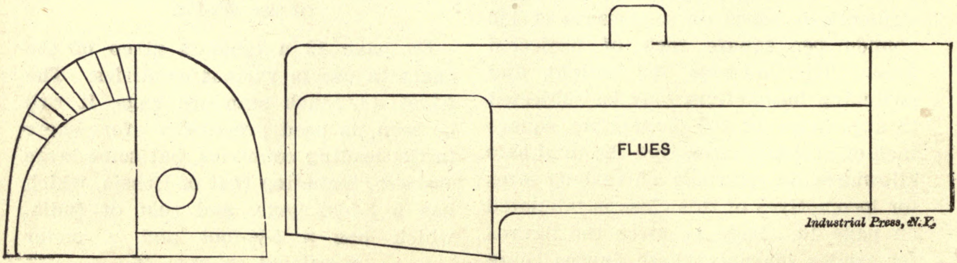

**WAGON TOP.**




**BELPAIRE.**



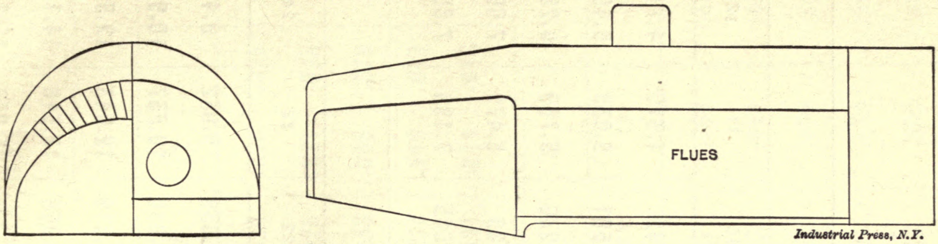

**EXTENDED FIREBOX.**



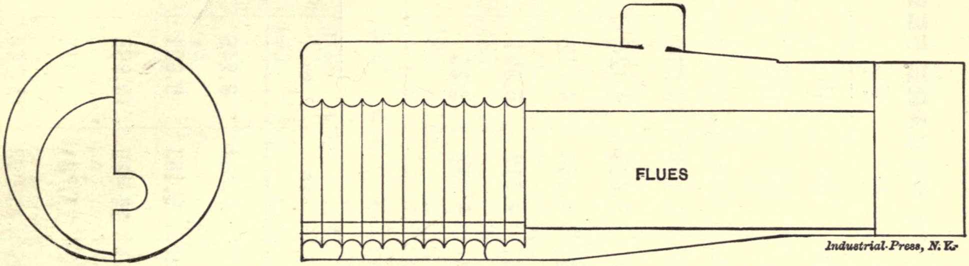

**WOOTEN WIDE FIREBOX.**

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 7 (Railway Edition). Explanatory note: Page 3.

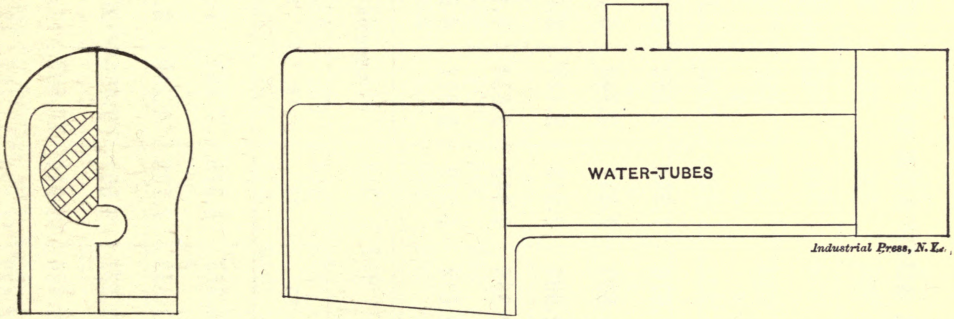
## TYPES OF LOCOMOTIVE BOILERS—II



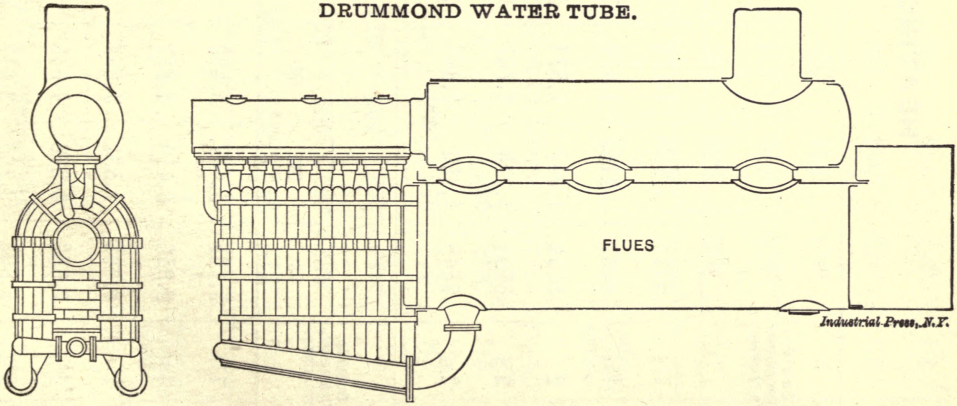

**WOOTEN LOW CROWN.**




**LENTZ OR VANDERBILT.**




**DRUMMOND WATER TUBE.**




**BROTAN.**

Contributed by Fred H. Colvin, MACHINERY's Data Sheet No. 7 (Railway Edition).

## HEATING SURFACE OF FLUES, IN SQUARE FEET.

| Outside Diameter in Inches. | LENGTH, FEET. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1½ | .3927 | .7854 | 1.178 | 1.570 | 1.963 | 2.356 | 2.748 | 3.141 | 3.534 | 3.92 | 4.319 | 4.712 |
| 1¾ | .4582 | .9163 | 1.374 | 1.832 | 2.291 | 2.748 | 3.207 | 3.665 | 4.123 | 4.581 | 5.039 | 5.497 |
| 2 | .5236 | 1.047 | 1.571 | 2.094 | 2.618 | 3.141 | 3.665 | 4.188 | 4.712 | 5.236 | 5.759 | 6.283 |
| 2¼ | .5891 | 1.178 | 1.767 | 2.356 | 2.945 | 3.534 | 4.123 | 4.712 | 5.301 | 5.89 | 6.479 | 7.068 |
| 2½ | .6545 | 1.309 | 1.963 | 2.618 | 3.272 | 3.927 | 4.581 | 5.236 | 5.89 | 6.545 | 7.199 | 7.854 |

| Outside Diameter, in Inches. | LENGTH, FEET. 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1½ | 5.105 | 5.497 | 5.890 | 6.283 | 6.675 | 7.068 | 7.461 | 7.854 | 8.246 | 8.639 | 9.032 | 9.424 |
| 1¾ | 5.956 | 6.414 | 6.872 | 7.330 | 7.788 | 8.246 | 8.705 | 9.163 | 9.621 | 10.080 | 10.537 | 10.996 |
| 2 | 6.806 | 7.330 | 7.854 | 8.377 | 8.901 | 9.424 | 9.948 | 10.472 | 10.995 | 11.519 | 12.043 | 12.566 |
| 2¼ | 7.657 | 8.246 | 8.835 | 9.424 | 10.014 | 10.603 | 11.192 | 11.781 | 12.370 | 12.959 | 13.548 | 14.137 |
| 2½ | 8.508 | 9.163 | 9.817 | 10.472 | 11.126 | 11.781 | 12.435 | 13.090 | 13.744 | 14.398 | 15.053 | 15.708 |

Contributed by B. J. Sinne, MACHINERY'S Data Sheet No. 12 (Railway Edition). Explanatory note: Page 3.

## HEATING SURFACE OF FLUES, IN SQUARE FEET (Continued).

| Outside Diameter, in Inches. | Length, Fractions of an Inch. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1/16 | 1/8 | 3/16 | 1/4 | 5/16 | 3/8 | 7/16 | 1/2 | 9/16 | 5/8 | 11/16 | 3/4 | 13/16 | 7/8 | 15/16 |
| 1½ | .002 | .004 | .006 | .008 | .010 | .012 | .014 | .016 | .018 | .020 | .022 | .024 | .026 | .028 | .031 |
| 1¾ | .002 | .005 | .007 | .009 | .012 | .014 | .017 | .019 | .021 | .024 | .026 | .028 | .031 | .033 | .036 |
| 2 | .003 | .005 | .008 | .011 | .013 | .016 | .019 | .022 | .024 | .027 | .030 | .033 | .035 | .038 | .041 |
| 2¼ | .003 | .006 | .009 | .012 | .015 | .018 | .021 | .024 | .028 | .031 | .034 | .037 | .040 | .043 | .046 |
| 2½ | .003 | .007 | .010 | .014 | .017 | .020 | .024 | .027 | .031 | .034 | .037 | .041 | .044 | .048 | .051 |

| Outside Diameter, in Inches. | Length, Inches. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1½ | .033 | .065 | .097 | .131 | .164 | .196 | .229 | .260 | .294 | .327 | .360 | .392 |
| 1¾ | .038 | .076 | .114 | .152 | .191 | .229 | .267 | .305 | .342 | .382 | .418 | .458 |
| 2 | .044 | .087 | .131 | .174 | .218 | .262 | .305 | .349 | .392 | .436 | .479 | .523 |
| 2¼ | .049 | .098 | .147 | .196 | .245 | .294 | .343 | .393 | .442 | .491 | .539 | .589 |
| 2½ | .054 | .119 | .163 | .218 | .272 | .327 | .381 | .436 | .490 | .540 | .599 | .654 |

Contributed by B. J. Sinne, MACHINERY'S Data Sheet No. 12 (Railway Edition). Explanatory note: Page 3.

# BEARING PRESSURE FOR LOCOMOTIVE JOURNALS.

**Based on Pressure of 160 Pounds per Square Inch of Projected Area. These Figures show the Safe Allowance for Engine Truck Journals of Passenger Locomotives.**

| Diameter of Journal. | LENGTH OF JOURNAL. 2″ | 3″ | 4″ | 5″ | 6″ | 7″ | 8″ | 9″ | 10″ | 11″ | 12″ | 13″ | 14″ | 15″ | 16″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2″ | 640 | 960 | 1280 | 1600 | 1920 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 2¼″ | 720 | 1080 | 1440 | 1800 | 2160 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 2½″ | 800 | 1200 | 1600 | 2000 | 2400 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 2¾″ | 880 | 1320 | 1760 | 2200 | 2640 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3″ | ..... | 1440 | 1920 | 2400 | 2880 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3¼″ | ..... | 1560 | 2080 | 2600 | 3120 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3½″ | ..... | 1680 | 2240 | 2800 | 3360 | 3920 | 4480 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3¾″ | ..... | ..... | 2400 | 3000 | 3600 | 4200 | 4800 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4″ | ..... | ..... | 2560 | 3200 | 3840 | 4480 | 5120 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4¼″ | ..... | ..... | 2720 | 3400 | 4080 | 4760 | 5440 | 6120 | 6800 | ..... | ..... | ..... | ..... | ..... | ..... |
| 4½″ | ..... | ..... | 2880 | 3600 | 4320 | 5040 | 5760 | 6480 | 7200 | ..... | ..... | ..... | ..... | ..... | ..... |
| 4¾″ | ..... | ..... | 3040 | 3800 | 4560 | 5320 | 6080 | 6840 | 7600 | ..... | ..... | ..... | ..... | ..... | ..... |
| 5″ | ..... | ..... | ..... | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 | 8800 | 9600 | ..... | ..... | ..... | ..... |
| 5½″ | ..... | ..... | ..... | ..... | ..... | 6160 | 7040 | 7920 | 8800 | 9680 | 10560 | ..... | ..... | ..... | ..... |
| 6″ | ..... | ..... | ..... | ..... | ..... | 6720 | 7680 | 8640 | 9600 | 10560 | 11520 | 12480 | ..... | ..... | ..... |
| 6½″ | ..... | ..... | ..... | ..... | ..... | 7280 | 8320 | 9360 | 10400 | 11440 | 12480 | 13520 | ..... | ..... | ..... |
| 7″ | ..... | ..... | ..... | ..... | ..... | 7840 | 8960 | 10080 | 11200 | 12320 | 13440 | 14560 | 15680 | ..... | ..... |
| 7½″ | ..... | ..... | ..... | ..... | ..... | 8400 | 9600 | 10800 | 12000 | 13200 | 14400 | 15600 | 16800 | ..... | ..... |
| 8″ | ..... | ..... | ..... | ..... | ..... | ..... | 10240 | 11520 | 12800 | 14080 | 15360 | 16640 | 17920 | 19200 | 20480 |
| 8½″ | ..... | ..... | ..... | ..... | ..... | ..... | 10880 | 12240 | 13600 | 14960 | 16320 | 17680 | 19040 | 20400 | 21760 |
| 9″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 12960 | 14400 | 15840 | 17280 | 18720 | 20160 | 21600 | 23040 |
| 9½″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 13680 | 15200 | 16720 | 18240 | 19760 | 21280 | 22800 | 24320 |
| 10″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 16000 | 17600 | 19200 | 20800 | 22400 | 24000 | 25600 |
| 10½″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 16800 | 18480 | 20160 | 21840 | 23520 | 25200 | 26880 |
| 11″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 19360 | 21120 | 22880 | 24640 | 26400 | 28160 |

Contributed by B. J. Sinne, MACHINERY'S Data Sheet No. 12 (Railway Edition). Explanatory note: Page 3.

# BEARING PRESSURE FOR LOCOMOTIVE JOURNALS.

**Based on Pressure of 180 Pounds per Square Inch of Projected Area. These Figures show the Safe Allowance for Driving and Trailing Journals of Passenger Locomotives.**

| Diameter of Journal. | LENGTH OF JOURNAL. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2″ | 3″ | 4″ | 5″ | 6″ | 7″ | 8″ | 9″ | 10″ | 11″ | 12″ | 13″ | 14″ | 15″ | 16″ |
| 2″ | 720 | 1080 | 1440 | 1800 | 2160 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 2¼″ | 810 | 1215 | 1620 | 2025 | 2430 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 2½″ | 900 | 1350 | 1800 | 2250 | 2700 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 2¾″ | 990 | 1485 | 1980 | 2475 | 2970 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3″ | ..... | 1620 | 2160 | 2700 | 3240 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3¼″ | ..... | 1755 | 2340 | 2925 | 3510 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3½″ | ..... | 1890 | 2520 | 3150 | 3780 | 4410 | 5040 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3¾″ | ..... | ..... | 2700 | 3375 | 4050 | 4725 | 5400 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4″ | ..... | ..... | 2880 | 3600 | 4320 | 5040 | 5760 | 6480 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4¼″ | ..... | ..... | 3060 | 3825 | 4590 | 5355 | 6120 | 6885 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4½″ | ..... | ..... | 3240 | 4050 | 4860 | 5670 | 6480 | 7290 | 8100 | ..... | ..... | ..... | ..... | ..... | ..... |
| 4¾″ | ..... | ..... | 3420 | 4275 | 5130 | 5985 | 6840 | 7695 | 8550 | ..... | ..... | ..... | ..... | ..... | ..... |
| 5″ | ..... | ..... | ..... | 4500 | 5400 | 6300 | 7200 | 8100 | 9000 | 9900 | 10800 | ..... | ..... | ..... | ..... |
| 5½″ | ..... | ..... | ..... | ..... | 5940 | 6930 | 7920 | 8910 | 9900 | 10890 | 11880 | ..... | ..... | ..... | ..... |
| 6″ | ..... | ..... | ..... | ..... | ..... | 7560 | 8640 | 9720 | 10800 | 11880 | 12960 | ..... | ..... | ..... | ..... |
| 6½″ | ..... | ..... | ..... | ..... | ..... | 8190 | 9360 | 10530 | 11700 | 12870 | 14040 | ..... | ..... | ..... | ..... |
| 7″ | ..... | ..... | ..... | ..... | ..... | 8820 | 10800 | 11340 | 12600 | 13860 | 15120 | ..... | ..... | ..... | ..... |
| 7½″ | ..... | ..... | ..... | ..... | ..... | 9450 | 10800 | 12150 | 13500 | 14850 | 16200 | ..... | ..... | ..... | ..... |
| 8″ | ..... | ..... | ..... | ..... | ..... | ..... | 11520 | 12960 | 14400 | 15840 | 17280 | ..... | ..... | ..... | ..... |
| 8½″ | ..... | ..... | ..... | ..... | ..... | ..... | 12240 | 13770 | 15300 | 16830 | 18360 | ..... | ..... | ..... | ..... |
| 9″ | ..... | ..... | ..... | ..... | ..... | ..... | 12960 | 14580 | 16200 | 17820 | 19440 | ..... | ..... | ..... | ..... |
| 9½″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 15390 | 17100 | 18810 | 20520 | 22230 | ..... | ..... | ..... |
| 10″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 18000 | 19800 | 21600 | 23400 | 25200 | 27000 | 28800 |
| 10½″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 18900 | 20790 | 22680 | 24570 | 26460 | 28350 | 30240 |
| 11″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 19800 | 21780 | 23760 | 25740 | 27720 | 29700 | 31680 |

Contributed by B. J. Sinne, MACHINERY'S Data Sheet No. 18 (Railway Edition). Explanatory note: Page 3.

# BEARING PRESSURES FOR LOCOMOTIVE JOURNALS.

**Based on Pressure of 200 Pounds per Square Inch of Projected Area. These Figures show the Safe Allowance for Driving, Engine Truck and Trailing Journals of Freight Locomotives and Switching Locomotives.**

| Diameter of Journal. | LENGTH OF JOURNAL. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2″ | 3″ | 4″ | 5″ | 6″ | 7″ | 8″ | 9″ | 10″ | 11″ | 12″ | 13″ | 14″ | 15″ | 16″ |
| 2″ | 800 | 1200 | 1600 | 2000 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 2¼″ | 900 | 1350 | 1800 | 2250 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 2½″ | 1000 | 1500 | 2000 | 2500 | 3000 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 2¾″ | 1100 | 1650 | 2200 | 2750 | 3300 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 3″ | .... | 1800 | 2400 | 3000 | 3600 | 4200 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 3¼″ | .... | 1950 | 2600 | 3250 | 3900 | 4550 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 3½″ | .... | 2100 | 2800 | 3500 | 4200 | 4900 | 5600 | .... | .... | .... | .... | .... | .... | .... | .... |
| 3¾″ | .... | .... | 3000 | 3750 | 4500 | 5250 | 6000 | .... | .... | .... | .... | .... | .... | .... | .... |
| 4″ | .... | .... | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | .... | .... | .... | .... | .... | .... | .... |
| 4¼″ | .... | .... | 3400 | 4250 | 5100 | 5950 | 6800 | 7650 | .... | .... | .... | .... | .... | .... | .... |
| 4½″ | .... | .... | 3600 | 4500 | 5400 | 6300 | 7200 | 8100 | 9000 | .... | .... | .... | .... | .... | .... |
| 4¾″ | .... | .... | 3800 | 4750 | 5700 | 6650 | 7600 | 8550 | 9500 | .... | .... | .... | .... | .... | .... |
| 5″ | .... | .... | .... | 5000 | 6000 | 7000 | 8000 | 9000 | 10000 | 11000 | 12000 | 13000 | 14000 | 15000 | 16000 |
| 5½″ | .... | .... | .... | 5500 | 6600 | 7700 | 8800 | 9900 | 11000 | 12100 | 13200 | 14300 | 15400 | 16500 | 17600 |
| 6″ | .... | .... | .... | .... | 7200 | 8400 | 9600 | 10800 | 12000 | 13200 | 14400 | 15600 | 16800 | 18000 | 19200 |
| 6½″ | .... | .... | .... | .... | 7800 | 9100 | 10400 | 11700 | 13000 | 14300 | 15600 | 16900 | 18200 | 19500 | 20800 |
| 7″ | .... | .... | .... | .... | .... | 9800 | 11200 | 12600 | 14000 | 15400 | 16800 | 18200 | 19600 | 21000 | 22400 |
| 7½″ | .... | .... | .... | .... | .... | 10500 | 12000 | 13500 | 15000 | 16500 | 18000 | 19500 | 21000 | 22500 | 24000 |
| 8″ | .... | .... | .... | .... | .... | .... | 12800 | 14400 | 16000 | 17600 | 19200 | 20800 | 22400 | 24000 | 25600 |
| 8½″ | .... | .... | .... | .... | .... | .... | 13600 | 15300 | 17000 | 18700 | 20400 | 22100 | 23800 | 25500 | 27200 |
| 9″ | .... | .... | .... | .... | .... | .... | .... | 16200 | 18000 | 19800 | 21600 | 23400 | 25200 | 27000 | 28800 |
| 9½″ | .... | .... | .... | .... | .... | .... | .... | 17100 | 19000 | 20900 | 22800 | 24700 | 26600 | 28500 | 30400 |
| 10″ | .... | .... | .... | .... | .... | .... | .... | .... | 20000 | 22000 | 24000 | 26000 | 28000 | 30000 | 32000 |
| 10½″ | .... | .... | .... | .... | .... | .... | .... | .... | 21000 | 23100 | 25200 | 27300 | 29400 | 31500 | 33600 |
| 11″ | .... | .... | .... | .... | .... | .... | .... | .... | 22000 | 24200 | 26400 | 28600 | 30800 | 33000 | 35200 |

Contributed by B. J. Sinne, MACHINERY'S Data Sheet No. 18 (Railway Edition). Explanatory note: Page 3.

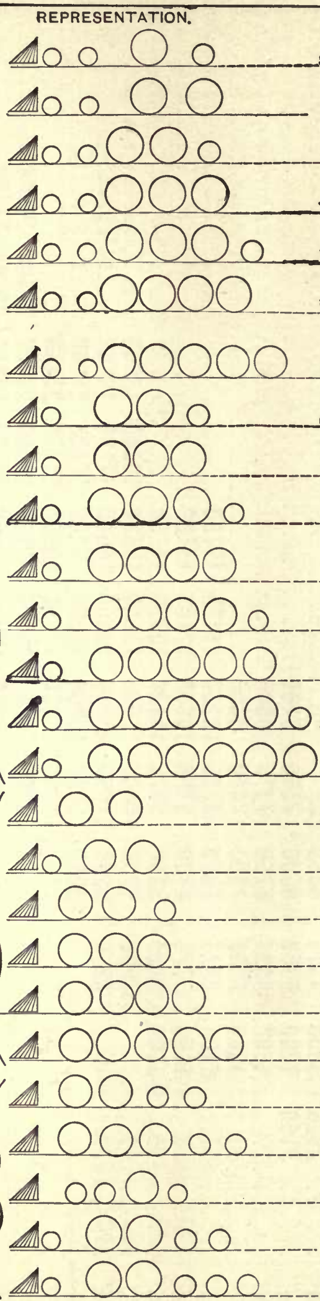
## BEARING PRESSURE FOR LOCOMOTIVE JOURNALS.

**Based on Pressure of 300 Pounds per Square Inch of Projected Area. These Figures show Safe Allowance for Tender Journals.**

| Diameter of Journal. | LENGTH OF JOURNAL. 2″ | 3″ | 4″ | 5″ | 6″ | 7″ | 8″ | 9″ | 10″ | 11″ | 12″ | 13″ | 14″ | 15″ | 16″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2″ | 1200 | 1800 | 2400 | 3000 | 3600 | | | | | | | | | | |
| 2¼″ | 1350 | 2025 | 2700 | 3375 | 4050 | | | | | | | | | | |
| 2½″ | 1500 | 2250 | 3000 | 3750 | 4500 | | | | | | | | | | |
| 2¾″ | 1650 | 2475 | 3300 | 4125 | 4950 | | | | | | | | | | |
| 3″ | | 2700 | 3600 | 4500 | 5400 | | | | | | | | | | |
| 3¼″ | | 2925 | 3900 | 4875 | 5850 | | | | | | | | | | |
| 3½″ | | 3150 | 4200 | 5250 | 6300 | 7350 | 8400 | | | | | | | | |
| 3¾″ | | | 4500 | 5625 | 6750 | 7875 | 9000 | | | | | | | | |
| 4″ | | | 4800 | 6000 | 7200 | 8400 | 9600 | | | | | | | | |
| 4¼″ | | | 5100 | 6375 | 7650 | 8925 | 10200 | 11475 | 12750 | | | | | | |
| 4½″ | | | 5400 | 6750 | 8100 | 9450 | 10800 | 12150 | 13500 | | | | | | |
| 4¾″ | | | 5700 | 7125 | 8550 | 9975 | 11400 | 12825 | 14250 | | | | | | |
| 5″ | | | | 7500 | 9000 | 10500 | 12000 | 13500 | 15000 | 16500 | 18000 | | | | |
| 5½″ | | | | 8250 | 9900 | 11550 | 13200 | 14850 | 16500 | 18150 | 19800 | | | | |
| 6″ | | | | | 10800 | 12600 | 14400 | 16200 | 18000 | 19800 | 21600 | | | | |
| 6½″ | | | | | 11700 | 13650 | 15600 | 17550 | 19500 | 21450 | 23400 | | | | |
| 7″ | | | | | | 14700 | 16800 | 18900 | 21000 | 23100 | 25200 | 27300 | 29400 | | |
| 7½″ | | | | | | 15750 | 18000 | 20250 | 22500 | 24750 | 27000 | 29250 | 31500 | | |
| 8″ | | | | | | | 19200 | 21600 | 24000 | 26400 | 28800 | 31200 | 33600 | | |
| 8½″ | | | | | | | 20400 | 23950 | 25500 | 28050 | 30600 | 33150 | 35700 | | |
| 9″ | | | | | | | 21600 | 24300 | 27000 | 29700 | 32400 | 35100 | 37800 | | |
| 9½″ | | | | | | | | 25650 | 28500 | 31350 | 34200 | 37050 | 39900 | | |
| 10″ | | | | | | | | | 30000 | 33000 | 36000 | 39000 | 42000 | 45000 | 48000 |
| 10½″ | | | | | | | | | 31500 | 34650 | 37800 | 40950 | 44100 | 47250 | 50400 |
| 11″ | | | | | | | | | | 36300 | 39600 | 42900 | 46200 | 49500 | 52800 |

Contributed by B. J. Sinne, MACHINERY'S Data Sheet No. 18 (Railway Edition). Explanatory note: Page 3.

## LOCOMOTIVE CLASSIFICATION



| CLASS | TYPE NAME. | WHYTE'S SYSTEM. | TOTAL WHEELS. |
|---|---|---|---|
| BOGIE CLASS | SINGLE DRIVER | 4-2-2 | 8 |
| | EIGHT-WHEEL (*American Type*) | 4-4-0 | 8 |
| | ATLANTIC | 4-4-2 | 10 |
| | TEN-WHEEL | 4-6-0 | 10 |
| | PACIFIC OR ST. PAUL | 4-6-2 | 12 |
| | TWELVE-WHEEL | 4-8-0 | 12 |
| | MASTODON | 4-10-0 | 14 |
| PONY CLASS | COLUMBIA | 2-4-2 | 8 |
| | MOGUL | 2-6-0 | 8 |
| | PRAIRIE | 2-6-2 | 10 |
| | CONSOLIDATION | 2-8-0 | 10 |
| | CALUMET OR MIKADO | 2-8-2 | 12 |
| | DECAPOD | 2-10-0 | 12 |
| | SANTA FE | 2-10-2 | 14 |
| | CENTIPEDE | 2-12-0 | 14 |
| SWITCHER CLASS | 4-WHEEL SWITCHER | 0-4-0 | 4 |
| | 4-COUPLED SWITCHER | 2-4-0 | 6 |
| | 4-COUPLED SWITCHER | 0-4-2 | 6 |
| | 6-WHEEL SWITCHER | 0-6-0 | 6 |
| | 8-WHEEL SWITCHER | 0-8-0 | 8 |
| | 10-WHEEL SWITCHER | 0-10-0 | 10 |
| FORNEY CLASS | FORNEY (original) | 0-4-4 | 8 |
| | FORNEY 6-COUPLED | 0-6-4 | 10 |
| | FORNEY-SINGLE | 4-2-2 | 8 |
| | MOGUL-FORNEY | 2-4-4 | 10 |
| | FORNEY-SUBURBAN | 2-4-6 | 12 |

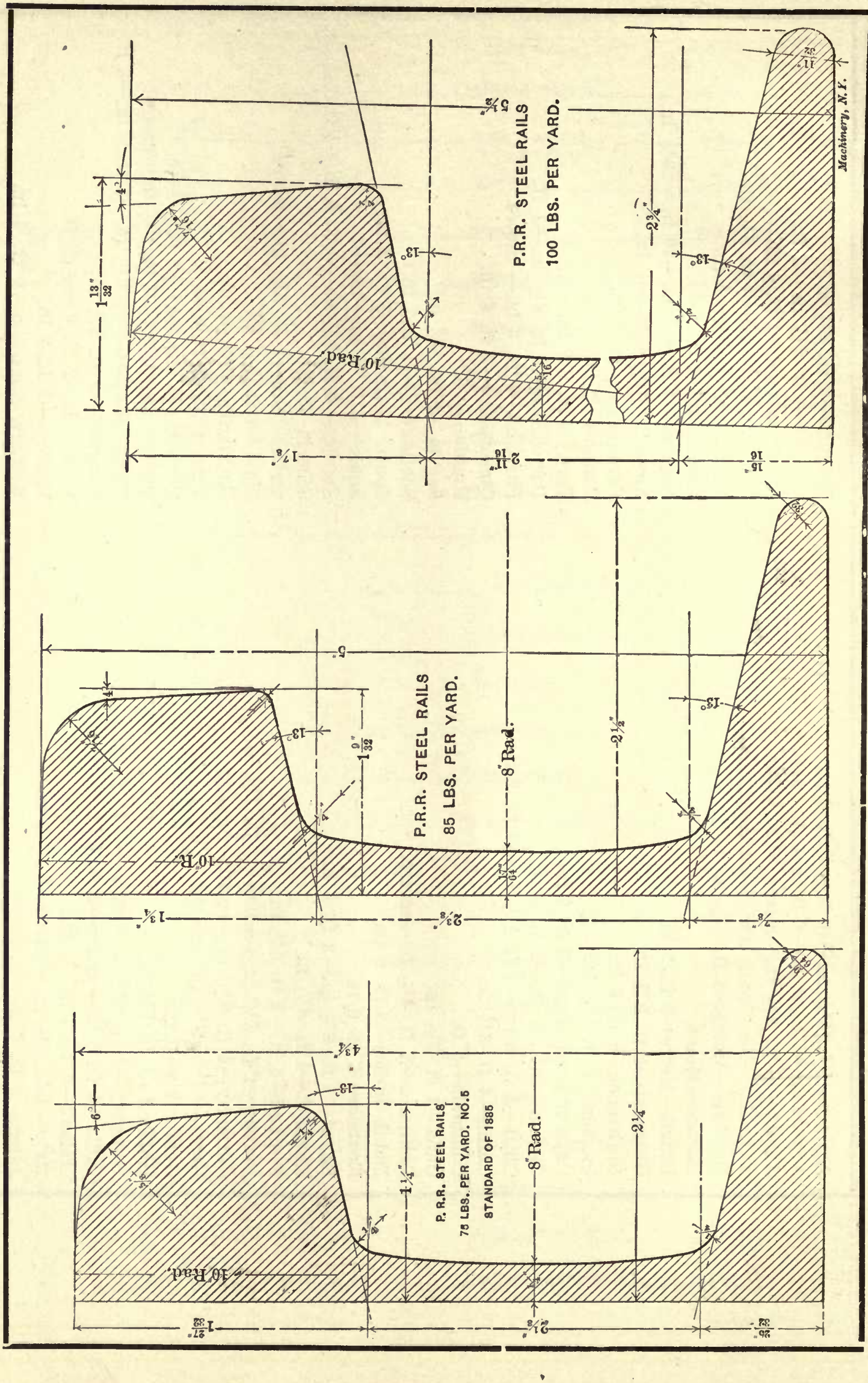
*Industrial Press, N.Y.*

## GAGES OF PRINCIPAL RAILROADS OF THE WORLD

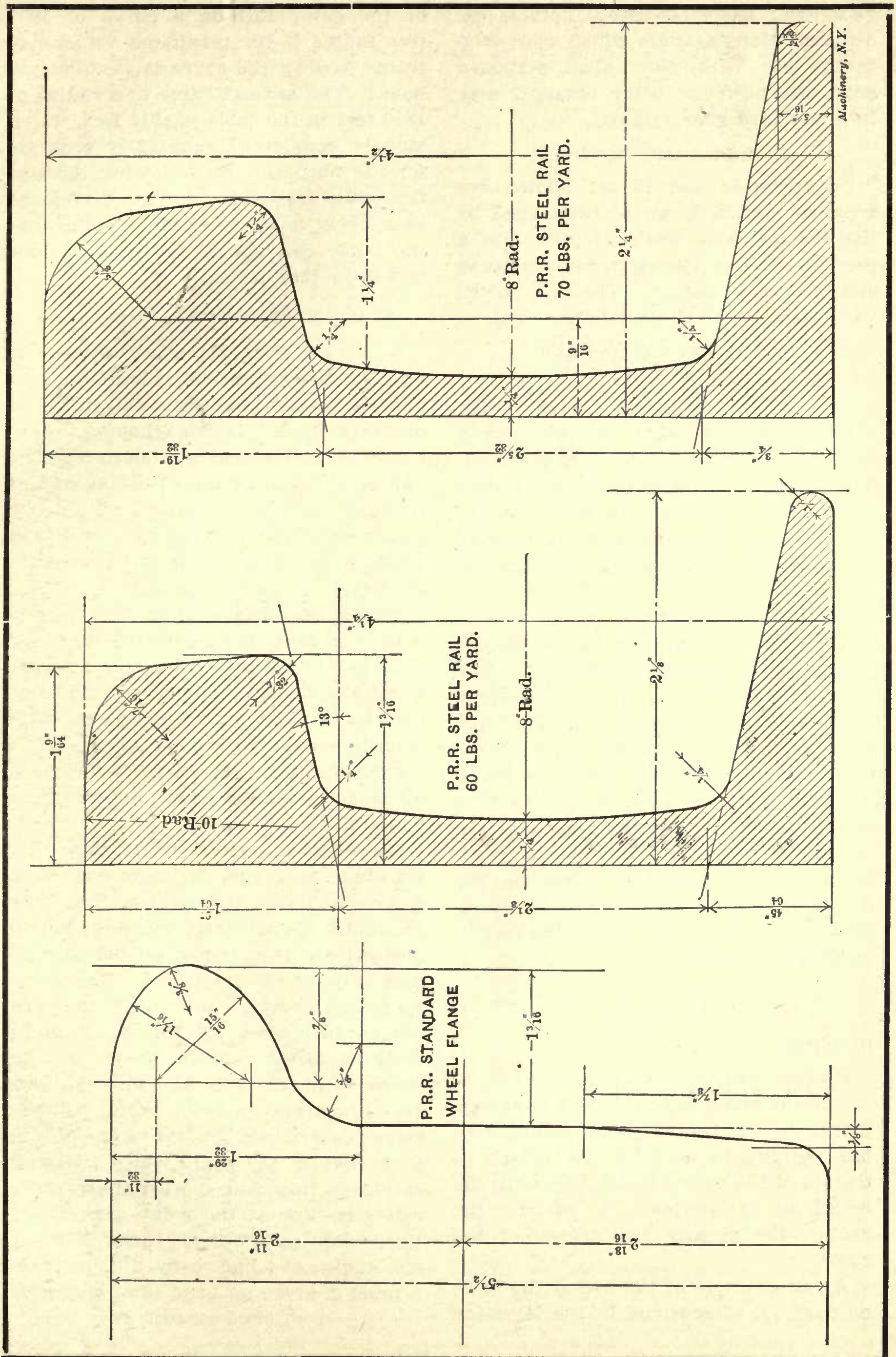
Algiers—4 ft. 8½ in.—40 in.—3 ft. 6 in.
Argentine—5 ft. 6 in.—4 ft. 8½ in.—metre.
Austria—4 ft. 8½ in.—metre—2 ft. 6 in.
Australia—See South and West Australia.
Belgium—Metre—4 ft. 8½ in.
Borneo—Metre.
Brazil—Metre—5 ft. 3 in.
Bulgaria—4 ft. 8½ in.
Barbadoes—2 ft. 6 in.
Canada—4 ft. 8½ in.
Cape of Good Hope—3 ft. 6 in.
Ceylon—5 ft. 6 in.—2 ft. 6 in.
Chili—5 ft. 6 in.—4 ft. 8½ in.—4 ft. 2 in
China—4 ft. 8½ in.
Columbia—3 ft.
Cuba—4 ft. 8½ in.
Denmark—4 ft. 8½ in.—metre.
Dutch Indies—3 ft. 6 in.
Ecuador—3 ft. 6 in.
Egypt—4 ft. 8½ in.—3 ft. 6 in.
England—4 ft. 8½ in.
Finland—5 ft.—2 ft. 5½ in.
France—4 ft. 8½ in.—metre—2 ft. 7½ in.
Germany—4 ft. 8½ in.—metre—29½ in.
Greece—4 ft. 8½ in.—metre.
Guatemala—3 ft.
Holland—4 ft. 8½ in.
Hungary—4 ft. 8½ in.—metre—2 ft. 6 in.
India—5 ft. 6 in.—metre—2 ft. 6 in.
Ireland—5 ft. 3 in.—3 ft.
Italy—4 ft. 8½ in.—metre—3 ft. 2 in.
Japan—3 ft. 6 in.
Jamaica—4 ft. 8½ in.
Mexico—4 ft. 8½ in.—3 ft.
Newfoundland—3 ft. 6 in.
New South Wales—4 ft. 8½ in.
New Zealand—3 ft. 6 in.
Nicaragua—3 ft. 6 in.
Norway—4 ft. 8½ in.—40 in.—29½ in.
Nova Scotia—4 ft. 8½ in.
Paraguay—5 ft. 6 in.
Panama—5 ft.
Peru—4 ft. 8½ in.—3 ft.
Porto Rico—4 ft. 8½ in.—3 ft.
Portugal—5 ft. 6 in.— metre.
Queensland—3 ft. 6 in.
Russia—5 ft.
Servia—4 ft. 8½ in.
Scotland—4 ft. 8½ in.
South Australia—5 ft. 3 in.
Spain—5 ft. 6 in.—metre.
Sweden—4 ft. 8½ in.—3 ft. 6 in.—2 ft. 7½ in.
Siberia—5 ft.
Switzerland—4 ft. 8½ in.—metre.
Siam—4 ft. 8½ in.
Tasmania—3 ft. 6 in.
Transvaal—3 ft. 6 in.
Turkey (in Europe)—4 ft. 8½ in.
Turkey (in Asia)—4 ft. 8½ in.—metre.
United States—4 ft. 8½ in.—4 ft. 9 in.—3 ft.
Uruguay—4 ft. 8½ in.
Venezuela—3 ft. 6 in.—2 ft.
Victoria—5 ft. 3 in.
Western Australia—3 ft. 6 in.

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 7 (Railway Edition). Explanatory note: Page 3.

## PENNSYLVANIA RAILROAD STANDARD RAIL SECTIONS—I



## PENNSYLVANIA RAILROAD STANDARD RAIL SECTIONS AND WHEEL FLANGES—II




MACHINERY'S Data Sheet No. 21 (Railway Edition). Explanatory note: Page 16.

(3.28-foot) gage, constitute notable exceptions. Many systems which were originally laid with other than standard gage are, however, being changed over into standard gage systems.

### Standard Rail Sections

On pages 14 and 15 are shown five types of standard rail sections used by the Pennsylvania Railroad, and also a section of the Pennsylvania Railroad standard wheel flange. The rails shown vary from 60 to 100 pounds per yard.

### Elevation on Outer Rail of Curves

On page 17 is given a table of the elevation of the outer rail on curves, for different velocities in miles per hour. The degree of the curve and the radius of the curve in feet are given in the two left-hand columns, and the velocity in miles per hour at the top of the columns.

The expression "degree of curve" may require some explanation to persons not familiar with railroad track work. The degree of a curve is the center angle that would be subtended by a chord 100 feet long. For curves from 1 to 10 degrees the radius may be found by dividing 5730 feet, which is the radius of a one-degree curve, by the degree of the curve. The results are sufficiently accurate for all practical purposes, but for sharp curves, that is, for those exceeding 10 degrees, the following formula should be used:

$$R = \frac{50}{\sin D}$$

in which

$R$ = the radius of the curve, and

$D$ = the angle of the curve in degrees.

It is evident that the degree of a curve has nothing to do with the length of the arc of the curve, but merely with the length of the radius. The shorter the radius, the greater the degree of the curve.

As an example of the use of the table on page 17, what would be the elevation of the outer rail on a curve of 1900 feet radius if the maximum velocity of trains passing the curve is 45 miles per hour? The nearest value to a radius of 1900 feet in the table is 1910 feet, which may be considered sufficiently accurate for the purpose. By following the line from 1910 feet to the column giving the velocity in miles per hour, we find that the outer rail should be elevated four inches in this case.

### Frogs, Switches and Cross-overs

As a rule, men who are primarily interested in machine construction are, for obvious reasons, not very well informed on track work. It often happens, however, that draftsmen, superintendents and others who have no training in this class of work are required to lay out, approve, or order industrial track systems to be used inside of a machine shop or in the yards outside. It is then necessary to decide upon the various details in connection with the frogs and switches, and some elementary information relating to this work will undoubtedly be of value to any man who is, or expects some day to be placed, in a responsible position where he may be occasionally called upon to carry out work of this character.

Switches are used for leading the wheels of cars from the main track onto a turn-out track. It is evident that when the outer switch rail reaches the opposite main rail, the wheel flange must pass through the main rail. The device by means of which the rail of the turn-out curve crosses the rail of the main track is called a frog, the general appearance of which is as shown on page 18. Frogs are made of various dimensions, determined by the angle of the frog, that is, the angle which the main rail gage line makes with the turn-out rail gage line at the point where these lines cross each other. Frogs of different angles are known by numbers, and a table is given on page 18 of frog num-

(Continued on page 24.)

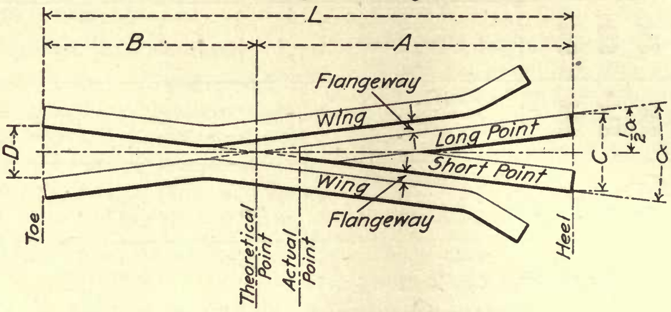
## ELEVATION OF OUTER RAIL ON CURVES IN INCHES.

| Curve. | | Velocity in Miles per Hour. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Deg. | Feet. | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | Deg. |
| 1 | 5730 | 0 | 1/8 | 1/4 | 3/8 | 5/8 | 3/4 | 1 1/8 | 1 3/8 | 1 5/8 | 2 | 2 3/8 | 2 3/4 | 3 1/4 | 1 |
| 2 | 2865 | 1/8 | 3/8 | 1/2 | 7/8 | 1 1/2 | 1 5/8 | 2 1/8 | 2 5/8 | 3 1/4 | 4 | 4 3/4 | 5 1/2 | 6 1/2 | 2 |
| 3 | 1910 | 1/4 | 1/2 | 3/4 | 1 1/4 | 1 3/4 | 2 3/8 | 3 1/8 | 4 | 4 7/8 | 6 | 7 1/8 | 8 3/8 | 9 3/4 | 3 |
| 4 | 1432 | 1/4 | 5/8 | 1 1/8 | 1 5/8 | 2 3/8 | 3 1/4 | 4 1/4 | 5 3/8 | 6 5/8 | 8 | 9 1/2 | ... | ... | 4 |
| 5 | 1146 | 3/8 | 3/4 | 1 1/4 | 2 | 3 | 4 | 5 1/4 | 6 5/8 | 8 1/4 | ... | ... | ... | ... | 5 |
| 6 | 955 | 3/8 | 1 | 1 5/8 | 2 1/2 | 3 1/2 | 4 7/8 | 6 1/4 | 8 | ... | ... | ... | ... | ... | 6 |
| 7 | 818 | 1/2 | 1 1/8 | 1 7/8 | 2 7/8 | 4 1/8 | 5 5/8 | 7 3/8 | ... | ... | ... | ... | ... | ... | 7 |
| 8 | 716 | 1/2 | 1 1/4 | 2 1/8 | 3 1/4 | 4 3/4 | 6 1/2 | 8 3/8 | ... | ... | ... | ... | ... | ... | 8 |
| 9 | 636 | 5/8 | 1 3/8 | 2 3/8 | 3 3/4 | 5 3/8 | 7 1/4 | ... | ... | ... | ... | ... | ... | ... | 9 |
| 10 | 573 | 3/4 | 1 1/2 | 2 5/8 | 4 1/8 | 5 7/8 | 8 1/8 | ... | ... | ... | ... | ... | ... | ... | 10 |
| 11 | 521 | 3/4 | 1 3/4 | 2 7/8 | 4 5/8 | 6 1/2 | 8 7/8 | ... | ... | ... | ... | ... | ... | ... | 11 |
| 12 | 477 | 7/8 | 1 7/8 | 3 1/8 | 4 7/8 | 7 1/8 | ... | ... | ... | ... | ... | ... | ... | ... | 12 |
| 13 | 441 | 7/8 | 2 | 3 3/8 | 5 3/8 | 7 3/4 | ... | ... | ... | ... | ... | ... | ... | ... | 13 |
| 14 | 409 | 1 | 2 1/8 | 3 3/8 | 5 3/4 | 8 3/8 | ... | ... | ... | ... | ... | ... | ... | ... | 14 |
| 15 | 382 | 1 | 2 1/4 | 3 7/8 | 6 1/4 | 8 7/8 | ... | ... | ... | ... | ... | ... | ... | ... | 15 |
| 16 | 358 | 1 1/8 | 2 1/2 | 4 1/4 | 6 5/8 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 16 |
| 17 | 337 | 1 1/4 | 2 5/8 | 4 1/2 | 7 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 17 |
| 18 | 318 | 1 1/4 | 2 3/4 | 4 3/4 | 7 1/2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 18 |
| 19 | 301 | 1 3/8 | 2 7/8 | 5 | 7 3/4 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 19 |
| 20 | 286 | 1 3/8 | 3 1/8 | 5 1/4 | 8 1/8 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 20 |

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 9 (Railway Edition). Explanatory note: Page 16.

## FROGS, SWITCHES AND CROSS-OVERS—I

### Rigid Frogs.




### Formulas for Rigid Frogs

N = no. of frog,
L = length over all,
C = heel spread,
D = toe spread,
$\alpha$ = angle of frog.

$$N = \frac{L}{C + D} \qquad \tan \tfrac{1}{2}\alpha = \frac{1}{2N}$$

$$C = 2A \times \tan \tfrac{1}{2}\alpha = \frac{A}{N}$$

$$D = 2B \times \tan \tfrac{1}{2}\alpha = \frac{B}{N}$$

There are three types of rigid frogs.

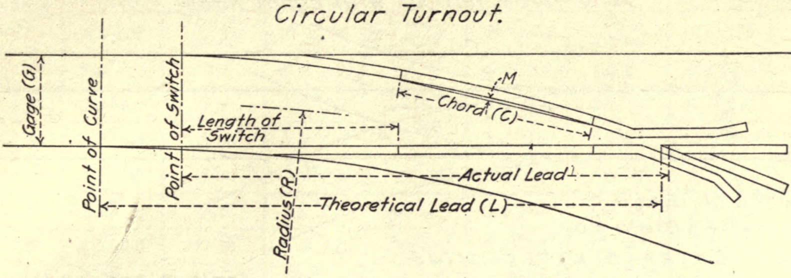
1. Bolted: Filling in flangeway and held together by bolts.
2. Clamped: Filling in flangeway and held together by clamps.
3. Riveted: Rail bases riveted to a base plate.

### Table of Frog Numbers and Angles.

| Number | Angle | Number | Angle | Number | Angle | Number | Angle | Number | Angle | Number | Angle |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $1\frac{1}{2}$ | 36° 52′ | 3 | 18° 55′ | 5 | 11° 25′ | 8 | 7° 09′ | 12 | 4° 46′ | 18 | 3° 11′ |
| $1\frac{3}{4}$ | 31° 53′ | $3\frac{1}{4}$ | 17° 30′ | $5\frac{1}{2}$ | 10° 23′ | $8\frac{1}{2}$ | 6° 44′ | 13 | 4° 24′ | 19 | 3° 01′ |
| 2 | 28° 04′ | $3\frac{1}{2}$ | 16° 16′ | 6 | 9° 32′ | 9 | 6° 22′ | 14 | 4° 05′ | 20 | 2° 52′ |
| $2\frac{1}{4}$ | 25° 03′ | $3\frac{3}{4}$ | 15° 11′ | $6\frac{1}{2}$ | 8° 48′ | $9\frac{1}{2}$ | 6° 02′ | 15 | 3° 49′ | | |
| $2\frac{1}{2}$ | 22° 37′ | 4 | 14° 15′ | 7 | 8° 10′ | 10 | 5° 43′ | 16 | 3° 35′ | | |
| $2\frac{3}{4}$ | 20° 37′ | $4\frac{1}{2}$ | 12° 41′ | $7\frac{1}{2}$ | 7° 38′ | 11 | 5° 12′ | 17 | 3° 22′ | | |

## FROGS, SWITCHES AND CROSS-OVERS—II

### Circular Turnout.




$G$ = gage (inside width between rail-heads),
$R$ = radius of curve,
$L$ = theoretical lead of switch,
$C$ = chord (see illustration above),
$M$ = middle ordinate (see illustration),
$N$ = number of frog (see Sheet I),
$\alpha$ = frog angle (see Sheet I),
$\delta$ = degree of curve.

$$L = 2G \times N = (R + \tfrac{1}{2}G)\sin\alpha$$

$$R = 2G \times N^2 = \frac{50}{\sin\frac{1}{2}\delta} = \frac{L^2}{2G}$$

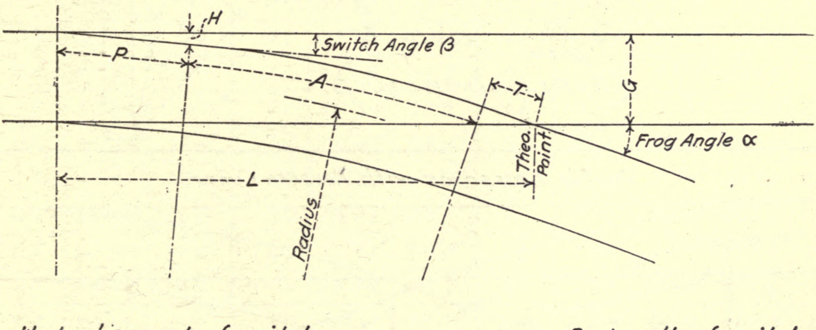
$$\cos\alpha = \frac{R - \frac{1}{2}G}{R + \frac{1}{2}G}\ ;\ \tan\tfrac{1}{2}\alpha = \frac{G}{L}$$

$$R = \frac{1}{2}\left(\frac{(\frac{1}{2}C)^2}{M} + M\right)$$

$$\sin\tfrac{1}{2}\delta = \frac{50}{R}$$

$$R = \frac{G}{\text{vers}\,\alpha} - \frac{1}{2}G$$

### Turnout Using Straight Frog and Switch.




$H$ = heel spread of switch,
$T$ = distance from theoretical point to toe of frog,

$$R + \tfrac{1}{2}G = \frac{G - H - T\sin\alpha}{\cos\beta - \cos\alpha}$$

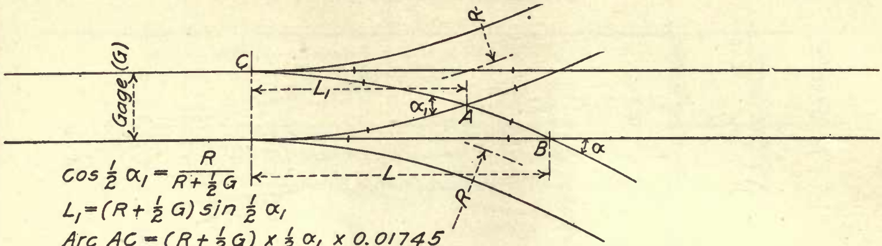
$$L = (R + \tfrac{1}{2}G)(\sin\alpha - \sin\beta) + (T \times \cos\alpha) + P$$

Length of arc $A = (\alpha - \beta)(R + \frac{1}{2}G) \times 0.01745$
($\alpha$ and $\beta$ are expressed in degrees)

$P$ = length of switch,
$\beta$ = switch angle.
Otherwise same notation as above.

## FROGS, SWITCHES AND CROSS-OVERS—III

### Three-Throw Turnout with Equal Radii.




$$\cos \tfrac{1}{2}\alpha_1 = \frac{R}{R+\frac{1}{2}G}$$

$$L_1 = (R+\tfrac{1}{2}G)\sin \tfrac{1}{2}\alpha_1$$

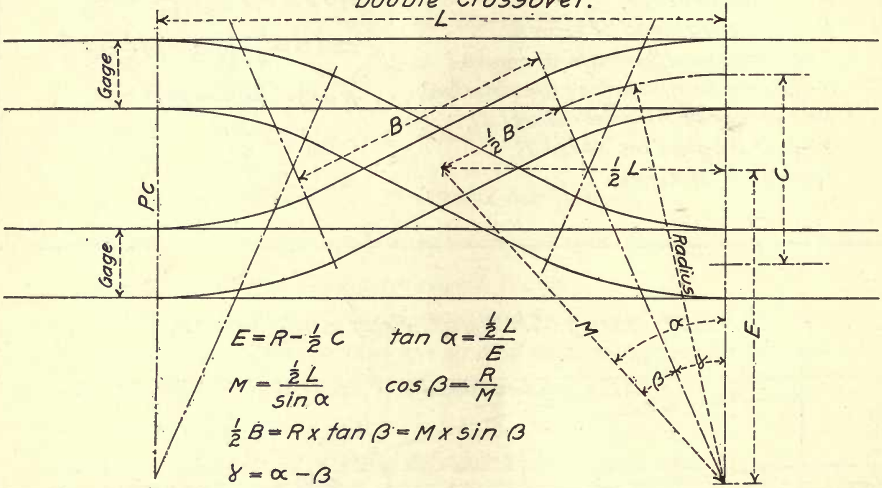
$$\text{Arc } AC = (R+\tfrac{1}{2}G) \times \tfrac{1}{2}\alpha_1 \times 0.01745$$

$$\text{Arc } AB = (R+\tfrac{1}{2}G) \times (\alpha - \tfrac{1}{2}\alpha_1) \times 0.01745$$

($\alpha$ and $\alpha_1$ are expressed in degrees)

Angle $\alpha$ and lead $L$ are found by the formulas given on Sheet II.

### Double Crossover.



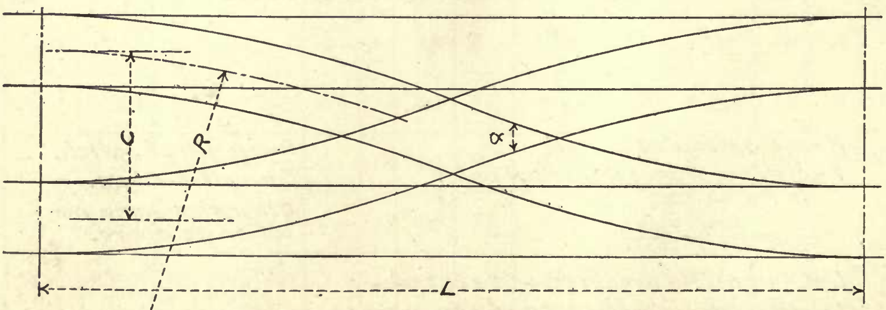

$$E = R - \tfrac{1}{2}C \qquad \tan\alpha = \frac{\frac{1}{2}L}{E}$$

$$M = \frac{\frac{1}{2}L}{\sin\alpha} \qquad \cos\beta = \frac{R}{M}$$

$$\tfrac{1}{2}B = R \times \tan\beta = M \times \sin\beta$$

$$\gamma = \alpha - \beta$$

### Double Crossover with Reverse Curve.




$$L = \sqrt{4RC - C^2} \qquad R = \frac{L^2 + C^2}{4C} \qquad \tan\tfrac{1}{2}\alpha = \frac{C}{L}$$

Contributed by Frank W. Holcomb, MACHINERY'S Data Sheet No. 131. Explanatory note: Page 16.

## FROGS, SWITCHES AND CROSS-OVERS—IV

| Radius, Feet | Gage 2'6" | | Gage 3'0" | | Gage 3'4" | | Gage 3'6" | |
|---|---|---|---|---|---|---|---|---|
| | Angle | Theo. Lead | Angle | Theo. Lead | Angle | Theo. Lead | Angle | Theo. Lead |
| 10 | 38°57' | 7'1" | 42°21' | 7'9" | 44°25' | 8'2" | 45°24' | 8'4" |
| 12 | 35°46' | 7'9" | 38°57' | 8'6" | 40°53' | 8'11" | 41°48' | 9'2" |
| 14 | 33°16' | 8'4" | 36°15' | 9'2" | 38°05' | 9'8" | 38°57' | 9'11" |
| 16 | 31°14' | 8'11" | 34°03' | 9'10" | 35°58' | 10'4" | 36°36' | 10'7" |
| 18 | 29°32' | 9'6" | 32°12' | 10'5" | 33°51' | 10'11" | 34°38' | 11'3" |
| 20 | 28°04' | 10'0" | 30°38' | 10'11" | 32°12' | 11'7" | 32°57' | 11'10" |
| 25 | 25°13' | 11'2" | 27°32' | 12'3" | 29°00' | 12'11" | 29°38' | 13'3" |
| 30 | 23°04' | 12'3" | 25°13' | 13'5" | 26°32' | 14'2" | 27°09' | 14'6" |
| 35 | 21°24' | 13'3" | 23°24' | 14'6" | 24°37' | 15'3" | 25°13' | 15'8" |
| 40 | 20°03' | 14'2" | 21°55' | 15'6" | 23°04' | 16'4" | 23°38' | 16'9" |
| 50 | 17°58' | 15'10" | 19°39' | 17'4" | 20°42' | 18'3" | 21°12' | 18'8" |
| 60 | 16°26' | 17'4" | 17°58' | 19'0" | 18°56' | 20'0" | 19°23' | 20'6" |
| 70 | 15°13' | 18'8" | 16°39' | 20'6" | 17°33' | 21'7" | 17°58' | 22'2" |
| 80 | 14°15' | 20'0" | 15°36' | 21'11" | 16°26' | 23'1" | 16°50' | 23'8" |
| 90 | 13°27' | 21'3" | 14°42' | 23'3" | 15°30' | 24'6" | 15°53' | 25'1" |
| 100 | 12°46' | 22'4" | 13°58' | 24'6" | 14°43' | 25'10" | 15°04' | 26'5" |

| Radius, Feet | Gage 3'8" | | Gage 4'8½" | | | Gage 4'8½" | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Angle | Theo. Lead | Radius, Feet | Angle | Theo. Lead | Number | Angle | Theo. Lead | Radius | Degree of Curve |
| 10 | 46°21' | 8'7" | 30 | 31°18' | 16'10" | 4 | 14°15' | 37'8" | 150.6' | 38°46' |
| 12 | 42°42' | 9'5" | 40 | 27°16' | 19'5" | 4½ | 12°41' | 42'4" | 190.6' | 30°24' |
| 14 | 39°47' | 10'2" | 50 | 24°29' | 21'8" | 5 | 11°25' | 47'1" | 235.4' | 24°32' |
| 16 | 37°24' | 10'10" | 60 | 22°24' | 23'9" | 5½ | 10°23' | 51'9" | 284.8' | 20°13' |
| 18 | 35°24' | 11'6" | 70 | 20°47' | 25'8" | 6 | 9°32' | 56'6" | 338.9' | 16°58' |
| 20 | 33°41' | 12'1" | 80 | 19°28' | 27'5" | 6½ | 8°48' | 61'2" | 397.8' | 14°26' |
| 25 | 30°18' | 13'6" | 90 | 18°22' | 29'1" | 7 | 8°10' | 65'11" | 461.3' | 12°27' |
| 30 | 27°46' | 14'10" | 100 | 17°27' | 30'8" | 7½ | 7°38' | 70'7" | 529.6' | 10°50' |
| 35 | 25°47' | 16'0" | 110 | 16°39' | 32'2" | 8 | 7°09' | 75'4" | 602.6' | 9°31' |
| 40 | 24°10' | 17'1" | 120 | 15°57' | 33'7" | 8½ | 6°44' | 80'0" | 680.3' | 8°26' |
| 50 | 21°41' | 19'2" | 130 | 15°20' | 35'0" | 9 | 6°22' | 84'9" | 762.6' | 7°31' |
| 60 | 19°50' | 21'0" | 140 | 14°39' | 36'4" | 9½ | 6°02' | 89'5" | 849.7' | 6°45' |
| 70 | 18°23' | 22'8" | 150 | 14°17' | 37'7" | 10 | 5°43' | 94'2" | 941.6' | 6°05' |
| 80 | 17°13' | 24'3" | 160 | 13°50' | 38'10" | 11 | 5°12' | 103'7" | 1139.3' | 5°02' |
| 90 | 16°15' | 25'8" | 170 | 13°25' | 40'0" | 12 | 4°46' | 113'0" | 1355.9' | 4°14' |
| 100 | 15°26' | 27'1" | 180 | 13°03' | 41'2" | | | | | |

Contributed by Frank W. Holcomb, MACHINERY'S Data Sheet No. 131. Explanatory note: Page 16.

# TABLE OF WEIGHT OF PLAIN TIRES.

| Diam. of Wheel Center. | 3 Inches Thick. | | 3½ Inches Thick. | | 4 Inches Thick. | | Diam. of Wheel Center. | 3 Inches Thick. | | 3½ Inches Thick, | | 4 Inches Thick. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 Ins. Wide. | 6½ Ins. Wide. | 6 Ins. Wide. | 6½ Ins. Wide. | 6 Ins. Wide. | 6½ Ins. Wide. | | 6 Ins. Wide. | 6½ Ins. Wide. | 6 Ins. Wide. | 6½ Ins. Wide. | 6 Ins. Wide. | 6½ Ins. Wide, |
| 21 | 413 | 446 | 487 | 526 | 563 | 609 | 53 | 963 | 1040 | 1122 | 1212 | 1283 | 1388 |
| 22 | 430 | 464 | 506 | 547 | 585 | 633 | 54 | 980 | 1059 | 1142 | 1234 | 1306 | 1412 |
| 23 | 447 | 483 | 526 | 569 | 608 | 657 | 55 | 997 | 1078 | 1162 | 1255 | 1328 | 1437 |
| 24 | 464 | 502 | 546 | 590 | 630 | 682 | 56 | 1014 | 1096 | 1182 | 1277 | 1351 | 1461 |
| 25 | 481 | 520 | 566 | 612 | 653 | 706 | 57 | 1031 | 1115 | 1202 | 1298 | 1373 | 1485 |
| 26 | 499 | 539 | 586 | 633 | 675 | 731 | 58 | 1049 | 1133 | 1221 | 1320 | 1396 | 1510 |
| 27 | 516 | 557 | 606 | 655 | 698 | 755 | 59 | 1066 | 1152 | 1241 | 1341 | 1418 | 1534 |
| 28 | 533 | 576 | 626 | 676 | 720 | 779 | 60 | 1083 | 1171 | 1261 | 1363 | 1441 | 1558 |
| 29 | 550 | 595 | 645 | 697 | 743 | 804 | 61 | 1100 | 1189 | 1281 | 1384 | 1463 | 1583 |
| 30 | 567 | 613 | 665 | 719 | 765 | 828 | 62 | 1117 | 1208 | 1301 | 1406 | 1486 | 1607 |
| 31 | 584 | 632 | 685 | 740 | 788 | 852 | 63 | 1135 | 1226 | 1321 | 1427 | 1508 | 1631 |
| 32 | 602 | 650 | 705 | 762 | 810 | 877 | 64 | 1152 | 1245 | 1341 | 1449 | 1531 | 1656 |
| 33 | 619 | 669 | 725 | 783 | 833 | 901 | 65 | 1169 | 1263 | 1360 | 1470 | 1553 | 1680 |
| 34 | 636 | 687 | 745 | 805 | 855 | 925 | 66 | 1186 | 1282 | 1380 | 1491 | 1576 | 1705 |
| 35 | 653 | 706 | 765 | 826 | 878 | 950 | 67 | 1203 | 1301 | 1400 | 1513 | 1598 | 1729 |
| 36 | 670 | 725 | 784 | 848 | 900 | 974 | 68 | 1220 | 1319 | 1420 | 1534 | 1621 | 1753 |
| 37 | 688 | 743 | 804 | 869 | 923 | 998 | 69 | 1238 | 1338 | 1440 | 1556 | 1643 | 1778 |
| 38 | 705 | 762 | 824 | 891 | 945 | 1023 | 70 | 1255 | 1356 | 1460 | 1577 | 1666 | 1802 |
| 39 | 722 | 780 | 844 | 912 | 968 | 1047 | 71 | 1272 | 1375 | 1480 | 1599 | 1688 | 1826 |
| 40 | 739 | 799 | 864 | 934 | 990 | 1071 | 72 | 1289 | 1394 | 1499 | 1620 | 1711 | 1851 |
| 41 | 756 | 818 | 884 | 955 | 1013 | 1096 | 73 | 1306 | 1412 | 1519 | 1642 | 1733 | 1875 |
| 42 | 774 | 836 | 904 | 976 | 1035 | 1120 | 74 | 1324 | 1431 | 1539 | 1663 | 1756 | 1899 |
| 43 | 791 | 855 | 923 | 998 | 1058 | 1144 | 75 | 1341 | 1449 | 1559 | 1685 | 1778 | 1925 |
| 44 | 808 | 873 | 943 | 1019 | 1080 | 1169 | 76 | 1358 | 1468 | 1579 | 1706 | 1801 | 1948 |
| 45 | 825 | 892 | 963 | 1041 | 1103 | 1193 | 77 | 1375 | 1486 | 1599 | 1728 | 1823 | 1972 |
| 46 | 842 | 910 | 983 | 1062 | 1126 | 1218 | 78 | 1392 | 1505 | 1619 | 1749 | 1846 | 1997 |
| 47 | 860 | 929 | 1003 | 1084 | 1148 | 1242 | 79 | 1410 | 1523 | 1638 | 1771 | 1868 | 2003 |
| 48 | 877 | 948 | 1023 | 1105 | 1171 | 1266 | 80 | 1427 | 1542 | 1658 | 1792 | 1891 | 2027 |
| 49 | 894 | 966 | 1043 | 1127 | 1193 | 1291 | 81 | 1444 | 1560 | 1678 | 1814 | 1913 | 2051 |
| 50 | 911 | 985 | 1063 | 1148 | 1216 | 1315 | 82 | 1461 | 1579 | 1698 | 1835 | 1936 | 2076 |
| 51 | 928 | 1003 | 1082 | 1170 | 1238 | 1339 | 83 | 1479 | 1597 | 1717 | 1857 | 1958 | 2100 |
| 52 | 945 | 1022 | 1102 | 1191 | 1261 | 1364 | 84 | 1496 | 1616 | 1737 | 1878 | 1981 | 2124 |

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 15 (Railway Edition). Explanatory note: Page 24.

## TABLE OF WEIGHT OF FLANGED TIRES.

| Diam. of Wheel Center. | 3 inches Thick. 5½ ins Wide. | 3 inches Thick. 5¾ ins. Wide | 3½ inches Thick. 5½ ins. Wide. | 3½ inches Thick. 5¾ ins. Wide | 4 inches Thick. 5½ ins. Wide. | 4 inches Thick. 5¾ ins. Wide | Diam. of Wheel Center. | 3 inches Thick. 5½ ins. Wide. | 3 inches Thick. 5¾ ins. Wide. | 3½ inches Thick. 5½ ins. Wide. | 3½ inches Thick. 5¾ ins. Wide. | 4 inches Thick. 5½ ins. Wide. | 4 inches Thick. 5¾ ins. Wide. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 401 | 417 | 469 | 489 | 540 | 562 | 53 | 936 | 974 | 1083 | 1127 | 1231 | 1282 |
| 22 | 418 | 435 | 489 | 508 | 562 | 585 | 54 | 953 | 991 | 1102 | 1147 | 1253 | 1304 |
| 23 | 435 | 452 | 508 | 528 | 583 | 607 | 55 | 970 | 1009 | 1121 | 1166 | 1274 | 1327 |
| 24 | 451 | 470 | 527 | 548 | 605 | 630 | 56 | 986 | 1026 | 1140 | 1186 | 1296 | 1349 |
| 25 | 468 | 487 | 546 | 568 | 626 | 652 | 57 | 1003 | 1043 | 1159 | 1206 | 1318 | 1372 |
| 26 | 485 | 504 | 565 | 588 | 648 | 675 | 58 | 1020 | 1060 | 1178 | 1226 | 1339 | 1394 |
| 27 | 502 | 522 | 584 | 608 | 670 | 697 | 59 | 1037 | 1078 | 1198 | 1246 | 1361 | 1417 |
| 28 | 518 | 539 | 604 | 628 | 691 | 720 | 60 | 1053 | 1096 | 1217 | 1266 | 1382 | 1439 |
| 29 | 535 | 556 | 623 | 648 | 713 | 742 | 61 | 1070 | 1113 | 1236 | 1286 | 1404 | 1462 |
| 30 | 551 | 574 | 642 | 668 | 734 | 765 | 62 | 1087 | 1130 | 1255 | 1306 | 1426 | 1484 |
| 31 | 568 | 591 | 661 | 688 | 756 | 787 | 63 | 1104 | 1148 | 1274 | 1326 | 1447 | 1507 |
| 32 | 585 | 609 | 680 | 708 | 778 | 810 | 64 | 1120 | 1165 | 1293 | 1346 | 1469 | 1529 |
| 33 | 602 | 626 | 699 | 728 | 799 | 832 | 65 | 1137 | 1183 | 1312 | 1366 | 1490 | 1552 |
| 34 | 619 | 643 | 718 | 748 | 821 | 855 | 66 | 1154 | 1200 | 1332 | 1386 | 1512 | 1574 |
| 35 | 635 | 661 | 738 | 768 | 842 | 877 | 67 | 1170 | 1217 | 1351 | 1406 | 1534 | 1597 |
| 36 | 652 | 678 | 757 | 788 | 864 | 900 | 68 | 1187 | 1235 | 1370 | 1426 | 1555 | 1619 |
| 37 | 669 | 696 | 776 | 808 | 886 | 922 | 69 | 1204 | 1252 | 1389 | 1446 | 1577 | 1642 |
| 38 | 686 | 713 | 795 | 828 | 907 | 945 | 70 | 1221 | 1269 | 1408 | 1466 | 1598 | 1664 |
| 39 | 702 | 730 | 814 | 847 | 929 | 967 | 71 | 1237 | 1287 | 1427 | 1486 | 1620 | 1687 |
| 40 | 719 | 748 | 833 | 867 | 950 | 990 | 72 | 1254 | 1304 | 1447 | 1505 | 1642 | 1709 |
| 41 | 736 | 765 | 853 | 887 | 972 | 1012 | 73 | 1271 | 1322 | 1466 | 1525 | 1663 | 1732 |
| 42 | 752 | 783 | 872 | 907 | 994 | 1035 | 74 | 1287 | 1339 | 1485 | 1545 | 1685 | 1754 |
| 43 | 769 | 800 | 891 | 927 | 1015 | 1057 | 75 | 1304 | 1356 | 1504 | 1565 | 1706 | 1777 |
| 44 | 786 | 817 | 910 | 947 | 1037 | 1080 | 76 | 1321 | 1374 | 1523 | 1585 | 1728 | 1799 |
| 45 | 803 | 835 | 929 | 967 | 1058 | 1102 | 77 | 1338 | 1391 | 1542 | 1605 | 1750 | 1822 |
| 46 | 819 | 852 | 948 | 987 | 1080 | 1125 | 78 | 1354 | 1409 | 1562 | 1625 | 1771 | 1844 |
| 47 | 836 | 870 | 968 | 1007 | 1102 | 1147 | 79 | 1371 | 1426 | 1581 | 1644 | 1793 | 1867 |
| 48 | 853 | 887 | 987 | 1027 | 1123 | 1169 | 80 | 1387 | 1444 | 1601 | 1664 | 1814 | 1889 |
| 49 | 869 | 904 | 1006 | 1047 | 1145 | 1192 | 81 | 1404 | 1462 | 1620 | 1684 | 1836 | 1901 |
| 50 | 886 | 922 | 1025 | 1067 | 1166 | 1214 | 82 | 1420 | 1479 | 1639 | 1704 | 1857 | 1924 |
| 51 | 903 | 939 | 1044 | 1087 | 1188 | 1237 | 83 | 1437 | 1497 | 1659 | 1723 | 1879 | 1946 |
| 52 | 920 | 956 | 1063 | 1107 | 1210 | 1259 | 84 | 1454 | 1514 | 1678 | 1743 | 1900 | 1968 |

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 15 (Railway Edition). Explanatory note: Page 24.

bers with their corresponding angles, the numbers being given from 1½ up to 20. Formulas are also given by means of which the frog number can be found when the angle is known, and the angle found when the frog number is known. As shown on page 18, dimension $L$ is the length along the center line. This is, theoretically, the correct dimension to be measured for determining the frog angle. In practice, however, the length is usually measured along the gage line, because of convenience in taking the measurement in this way. As the angles are small, approximately correct results are obtained by inserting the dimension thus obtained in place of $L$ in the formulas.

A circular turn-out is shown on page 19. In the illustration the various dimensions, such as theoretical lead, actual lead, radius, etc., are defined, and formulas for finding each are given. When a turn-out of this kind is being laid out, the angle can be determined when the radius and the gage are known, and when the angle has been found the corresponding frog to be used, as defined by its number, is determined from the table already referred to. The lower part on page 19 gives formulas for a turn-out using straight frog and switch. In this case the formulas are somewhat more complicated than in the simple circular turn-out.

On page 20 is shown a diagram of a three-throw turn-out, and formulas are given for determining the angle between the outer rails of the two turn-out curves. In the lower part of the same table is a diagram of a double crossover with straight crossing and curved switches, and also for a double crossover with reverse curve, formulas for the required angles and dimensions being given for both. On page 21 some of the dimensions which can be found by the formulas given in the previous tables have been tabulated and collected for six different gages. These tables give the radius in feet, the angle in degrees and minutes and the theoretical lead in feet and inches. A special table for 4-foot 8½-inch, or standard gage, is also included, which gives the number of frog, the corresponding angle, the theoretical lead, the radius of the turn-out curve and the degree of the curve.

### Tables of Weights of Tires

On pages 22 and 23 are given two tables of the weights of tires of various dimensions, the table on page 22 being for plain tires, and that on page 23 for flanged tires. For example, if the diameter of the wheel center is 59 inches, then a plain tire 3 1/2 inches thick, and 6 1/2 inches wide will weigh approximately 1341 pounds, as found from the table on page 22. A flanged tire of the same dimensions, except only 5 3/4 inches wide, would weigh 1246 pounds, as found from the table on page 23.

### Allowances for Shrinkage of Tires

The term "shrinking fit" is applied when a part which is to be held in position by being tightly fitted in a hole, is first turned a few thousandths of an inch larger than the hole, and then the diameter of the hole increased by heating, after which the central part is inserted into the heated part. When the outside part cools down, the consequent contraction of the metal causes it to grip the central part with a tremendous pressure. Locomotive tires are attached to their wheel centers by means of a shrinking fit. On page 25 are given the allowances for shrinkage for different diameters of tires. For example, if the wheel center is 40 inches in diameter, then the inside diameter of the tire should be made 39.958 inches, an allowance of 0.042 inch being made for shrinkage.

### Tables of Speeds of Trains

On pages 26 and 27 are given two tables which will be found useful when making calculations relating to the speed

(Continued on page 38.)

## PROPER ALLOWANCE FOR SHRINKAGE OF TIRES.

| Diameter of Wheel Center. | Inside Diameter of Tire, | Allowance for Shrinkage. | Diameter of Wheel Center. | Inside Diameter of Tire. | Allowance for Shrinkage. |
|---|---|---|---|---|---|
| 20 | 19.979 | .021 | 53 | 52.945 | .055 |
| 21 | 20.978 | .022 | 54 | 53.944 | .056 |
| 22 | 21.977 | .023 | 55 | 54.943 | .057 |
| 23 | 22.976 | .024 | 56 | 55.942 | .058 |
| 24 | 23.975 | .025 | 57 | 56.941 | .059 |
| 25 | 24.974 | .026 | 58 | 57.940 | .060 |
| 26 | 25.973 | .027 | 59 | 58.939 | .061 |
| 27 | 26.972 | .028 | 60 | 59.937 | .063 |
| 28 | 27.971 | .029 | 61 | 60.936 | .064 |
| 29 | 28.970 | .030 | 62 | 61.935 | .065 |
| 30 | 29.969 | .031 | 63 | 62.934 | .066 |
| 31 | 30.968 | .032 | 64 | 63.933 | .067 |
| 32 | 31.967 | .033 | 65 | 64.932 | .068 |
| 33 | 32.966 | .034 | 66 | 65.931 | .069 |
| 34 | 33.965 | .035 | 67 | 66.930 | .070 |
| 35 | 34.964 | .036 | 68 | 67.929 | .071 |
| 36 | 35.962 | .038 | 69 | 68.928 | .072 |
| 37 | 36.961 | .039 | 70 | 69.927 | .073 |
| 38 | 37.960 | .040 | 71 | 70.926 | .074 |
| 39 | 38.959 | .041 | 72 | 71.925 | .075 |
| 40 | 39.958 | .042 | 73 | 72.924 | .076 |
| 41 | 40.957 | .043 | 74 | 73.923 | .077 |
| 42 | 41.956 | .044 | 75 | 74.922 | .078 |
| 43 | 42.955 | .045 | 76 | 75.921 | .079 |
| 44 | 43.954 | .046 | 77 | 76.920 | .080 |
| 45 | 44.953 | .047 | 78 | 77.919 | .081 |
| 46 | 45.952 | .048 | 79 | 78.918 | .082 |
| 47 | 46.951 | .049 | 80 | 79.917 | .083 |
| 48 | 47.950 | .050 | 81 | 80.916 | .084 |
| 49 | 48.949 | .051 | 82 | 81.915 | .085 |
| 50 | 49.948 | .052 | 83 | 82.914 | .086 |
| 51 | 50.947 | .053 | 84 | 83.912 | .088 |
| 52 | 51.946 | .054 | .. | ...... | .... |

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 15 (Railway Edition). Explanatory note: Page 24.

# EQUIVALENTS OF TIME AND SPACE TRAVERSED.

| Miles per Hour. | Feet per Hour. | Feet per Minute. | Feet per Second. | Time per Mile. | | Time per Mile. | Miles per Hour. | Feet per Hour. | Feet per Minute. | Feet per Second. | Time per Mile. | | Time per Mile. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min. | Sec. | Seconds. | | | | | Min. | Sec. | Seconds. |
| 1 | 5,280 | 88 | 1.46 | 60 | .. | 3,600 | 31 | 163,680 | 2,728 | 45.46 | 1 | 56 | 116 |
| 2 | 10,560 | 176 | 2.92 | 30 | .. | 1,800 | 32 | 168,960 | 2,816 | 46.92 | 1 | 52 | 112 |
| 3 | 15,840 | 264 | 4.38 | 20 | .. | 1,200 | 33 | 174,240 | 2,904 | 48.38 | 1 | 49 | 109 |
| 4 | 21,120 | 352 | 5.86 | 15 | .. | 900 | 34 | 179,520 | 2,992 | 49.86 | 1 | 45 | 105 |
| 5 | 26,460 | 440 | 7.32 | 12 | .. | 720 | 35 | 184,800 | 3,080 | 51.33 | 1 | 42 | 102 |
| 6 | 31,680 | 528 | 8.80 | 10 | .. | 600 | 36 | 190,080 | 3.168 | 52.80 | 1 | 40 | 100 |
| 7 | 36.960 | 616 | 10.26 | 8 | 34 | 514 | 37 | 195,360 | 3,256 | 54.26 | 1 | 37 | 97 |
| 8 | 42,240 | 704 | 11.73 | 7 | 30 | 450 | 38 | 200,640 | 3,344 | 55.73 | 1 | 34 | 94 |
| 9 | 47,520 | 792 | 13.19 | 6 | 40 | 400 | 39 | 205,920 | 3,432 | 57.19 | 1 | 32 | 92 |
| 10 | 52,800 | 880 | 14.66 | 6 | .. | 360 | 40 | 211,200 | 3,520 | 58.66 | 1 | 30 | 90 |
| 11 | 58,080 | 968 | 16.12 | 5 | 27 | 327 | 41 | 216,480 | 3,608 | 60.12 | 1 | 27 | 87 |
| 12 | 63,360 | 1,056 | 17.60 | 5 | .. | 300 | 42 | 221,760 | 3,696 | 61.60 | 1 | 25 | 85 |
| 13 | 68,640 | 1,144 | 19.06 | 4 | 36 | 276 | 43 | 227,040 | 3,784 | 63.06 | 1 | 23 | 83 |
| 14 | 73,920 | 1,232 | 20.52 | 4 | 17 | 257 | 44 | 232,320 | 3,872 | 64 52 | 1 | 21 | 81 |
| 15 | 79,200 | 1,320 | 22.00 | 4 | .. | 240 | 45 | 237,600 | 3,960 | 66.00 | 1 | 20 | 80 |
| 16 | 84,480 | 1,408 | 23.46 | 3 | 45 | 225 | 46 | 242,880 | 4,048 | 67.46 | 1 | 18 | 78 |
| 17 | 89,760 | 1,496 | 24.92 | 3 | 31 | 211 | 47 | 248,160 | 4,136 | 68.92 | 1 | 16 | 76 |
| 18 | 95,040 | 1.584 | 26.38 | 3 | 20 | 200 | 48 | 253,440 | 4.224 | 70.38 | 1 | 15 | 75 |
| 19 | 100,320 | 1,672 | 27.86 | 3 | 9 | 189 | 49 | 258,720 | 4,312 | 71.86 | 1 | 13 | 73 |
| 20 | 105,600 | 1,760 | 29.33 | 3 | .. | 180 | 50 | 264,000 | 4,400 | 73.33 | 1 | 12 | 72 |
| 21 | 110,880 | 1,848 | 30.80 | 2 | 51 | 171 | 51 | 269,280 | 4 488 | 74.80 | 1 | 10 | 70 |
| 22 | 116,160 | 1,936 | 32.26 | 2 | 43 | 163 | 52 | 274,560 | 4,576 | 76.26 | 1 | 9 | 69 |
| 23 | 121,440 | 2,024 | 33.73 | 2 | 36 | 156 | 53 | 279 840 | 4,664 | 77.73 | 1 | 7 | 67 |
| 24 | 126,720 | 2,112 | 35.19 | 2 | 30 | 150 | 54 | 285,120 | 4,752 | 79.19 | 1 | 6 | 66 |
| 25 | 132,000 | 2,200 | 36.66 | 2 | 24 | 144 | 55 | 290 400 | 4,840 | 80.66 | 1 | 5 | 65 |
| 26 | 137,280 | 2,288 | 38.12 | 2 | 18 | 138 | 56 | 295,680 | 4,928 | 82.12 | 1 | 4 | 64 |
| 27 | 142,560 | 2,376 | 39.60 | 2 | 13 | 133 | 57 | 300,960 | 5 016 | 83.60 | 1 | 3 | 63 |
| 28 | 147,840 | 2,464 | 41.06 | 2 | 8 | 128 | 58 | 306,240 | 5,104 | 85.06 | 1 | 2 | 62 |
| 29 | 153,120 | 2,552 | 42.52 | 2 | 4 | 124 | 59 | 311,520 | 5,192 | 86.52 | 1 | 1 | 61 |
| 30 | 158,400 | 2,640 | 44.00 | 2 | .. | 120 | 60 | 316,800 | 5,280 | 88.00 | 1 | .. | 60 |

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 9 (Railway Edition). Explanatory note: Page 24.

## ROTATIVE SPEED TABLE FOR MILES PER HOUR.

| Diameter in inches. | Circumference in feet. | Revolutions per mile. | Revolutions per Minute at Miles per Hour. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10 | 15 | 25 | 35 | 40 | 55 | 65 | 75 |
| 18 | 4.712 | 1119.76 | 186.62 | 279.94 | 466.55 | 653.17 | 746.48 | 1026.42 | 1213.03 | 1399.65 |
| 20 | 5.236 | 1008.4 | 168.07 | 252.1 | 420.17 | 588.24 | 672.28 | 924.38 | 1092.45 | 1260.52 |
| 22 | 5.759 | 916.8 | 152.4 | 229.2 | 381.6 | 534. | 609.6 | 838.8 | 991.2 | 1143.6 |
| 24 | 6.283 | 838.4 | 139.7 | 209.6 | 349.3 | 489. | 558.8 | 767.4 | 908.1 | 1047.8 |
| 26 | 6.81 | 775.3 | 129.2 | 193.8 | 323. | 452.2 | 516.8 | 710.6 | 839.8 | 969. |
| 28 | 7.36 | 720.3 | 120. | 180.1 | 300.1 | 420.1 | 480. | 660.1 | 780.1 | 900.1 |
| 30 | 7.85 | 672.6 | 112.1 | 168.15 | 280.25 | 392.35 | 448.4 | 616.55 | 728.65 | 840.75 |
| 32 | 8.377 | 630.3 | 105.05 | 157.57 | 262.62 | 367.67 | 420.2 | 577.77 | 682.82 | 787.87 |
| 33 | 8.64 | 611.1 | 101.85 | 152.8 | 254.65 | 356.5 | 407.40 | 560.2 | 662.05 | 763.9 |
| 34 | 8.901 | 593.2 | 98.8 | 148.3 | 247.1 | 345.9 | 395.2 | 543.5 | 642.3 | 741.1 |
| 36 | 9.42 | 560.5 | 93.4 | 140.1 | 233.5 | 326.9 | 373.6 | 513.7 | 607.1 | 700.5 |
| 37 | 9.686 | 545.1 | 90.8 | 136.3 | 227.1 | 317.9 | 363.2 | 499.5 | 590.3 | 681.1 |
| 38 | 9.95 | 530.6 | 88.4 | 132.4 | 220.8 | 309.2 | 353.6 | 486. | 574.4 | 662.8 |
| 40 | 10.47 | 504.2 | 84.03 | 126.05 | 210 08 | 294.11 | 336.12 | 462.17 | 546.2 | 630.23 |
| 42 | 11.00 | 480.0 | 80. | 120. | 200. | 280. | 320. | 440. | 520. | 600. |
| 44 | 11.52 | 458.3 | 76.4 | 114.5 | 191. | 267.4 | 305.6 | 420.1 | 496.6 | 573. |
| 46 | 12.04 | 438.5 | 73.1 | 109.6 | 182.7 | 255.8 | 292.4 | 402. | 475.1 | 548.2 |
| 48 | 12.57 | 420.0 | 70. | 105. | 180. | 250. | 280. | 385. | 460. | 530. |
| 50 | 13.00 | 403.4 | 67.2 | 100.85 | 168. | 235.2 | 268.8 | 369.65 | 436.8 | 504. |
| 52 | 13.61 | 387.9 | 64.6 | 97. | 161.6 | 226.2 | 258.4 | 355.4 | 420. | 484.6 |
| 54 | 14.14 | 373.4 | 62.2 | 93.3 | 155.5 | 217.7 | 248.8 | 342 1 | 404.3 | 466.5 |
| 56 | 14.66 | 360.2 | 60.03 | 90.05 | 150.1 | 210.13 | 240.12 | 330.17 | 390.22 | 450.25 |
| 58 | 15.18 | 347.8 | 57.9 | 86.9 | 144.8 | 202.7 | 231.6 | 318 5 | 376.4 | 434.3 |
| 60 | 15.71 | 336.1 | 56.01 | 84.02 | 141. | 197.01 | 224.04 | 308.1 | 365.04 | 421.05 |
| 62 | 16.23 | 325.3 | 54.2 | 81.3 | 135.5 | 189.7 | 216.8 | 298.1 | 352.3 | 406.5 |
| 64 | 16.75 | 315.2 | 52.5 | 78.7 | 131.2 | 183.7 | 210. | 288.7 | 341.2 | 393.7 |
| 66 | 17.28 | 305.5 | 50.9 | 76.4 | 127.3 | 178.2 | 203.6 | 280. | 330.9 | 381.8 |
| 68 | 17.80 | 296.6 | 49.4 | 74.1 | 123.5 | 173. | 197.6 | 271.7 | 321.1 | 370.6 |
| 70 | 18.36 | 288.1 | 48.0 | 72. | 120. | 168. | 192. | 264. | 312. | 360. |
| 72 | 18.85 | 280.1 | 46.7 | 70. | 116.7 | 163.4 | 186.8 | 256.8 | 303.5 | 350.2 |
| 78 | 20.42 | 258.6 | 43.1 | 64.6 | 107.7 | 150.8 | 172.4 | 237. | 280.1 | 323.2 |
| 84 | 21.99 | 240.1 | 40. | 60. | 100. | 140. | 160. | 220. | 260. | 300. |
| 90 | 23.56 | 224.1 | 37.3 | 56. | 92.3 | 129.6 | 149.2 | 205.2 | 241.5 | 278.8 |
| 96 | 25.16 | 210.1 | 35. | 52.5 | 87.5 | 122.5 | 140. | 192.5 | 227.5 | 262.5 |

The rate of miles per hour has been so chosen that by doubling any of them the intermediate speeds of 20, 30, 50, 70, 80, etc., can be had. The column of revolutions per mile gives revolutions per minute for 60 miles per hour. Almost any other speed can be found by adding two columns such as 10 and 75.

Contributed by Fred H. Colvin, MACHINERY's Data Sheet No. 9 (Railway Edition). Explanatory note: Page 24.

# GRADES AND EFFECT ON HAULING CAPACITY.

| GRADES. | | | | LOADS. Tons Hauled per 1000 pounds on Drivers. | |
|---|---|---|---|---|---|
| Per Cent. 1 | Feet per Mile. 2 | Length to Rise of 1 Foot. 3 | Resistance in pounds per ton at 10 Miles per Hour. 4 | 5 | 6 |
| .1 | 5.28 | 1000. | 6.5 | 38.4 | 30.8 |
| .5 | 26.4 | 200. | 14.1 | 17.7 | 14.1 |
| 1. | 52.8 | 100. | 23.6 | 10.6 | 8.4 |
| 1.5 | 79.2 | 66.66 | 34.7 | 7.2 | 5.7 |
| 2. | 105.6 | 50. | 44.5 | 5.5 | 4.4 |
| 2.5 | 132. | 40. | 54. | 4.6 | 3.6 |
| 3. | 158.4 | 33.33 | 69.9 | 3.8 | 3. |
| 3.5 | 184.8 | 28.57 | 74.5 | 3.3 | 2.4 |
| 4. | 211.2 | 25. | 84.3 | 2.9 | 2.3 |
| 4.5 | 237.6 | 22.22 | 94.7 | 2.7 | 2.1 |
| 5. | 264. | 20. | 104.6 | 2.3 | 1.8 |
| 5.5 | 290.4 | 18.18 | 114.7 | 2.1 | 1.7 |
| 6. | 316.8 | 16.66 | 124.9 | 2. | 1.6 |

Columns 1, 2, 3 and 4 explain themselves. Column 5 is based on the assumption that tractive power is one-quarter the weight on drivers. Column 6 is similar except that one-fifth the weight on drivers is assumed and it is therefore a more conservative calculation.

Resistance equals .3788 pounds per ton for a straight grade of 1 foot per mile.

## CURVES

| Degree. | Radius. | Equivalent to Grade of (Feet per mile.) |
|---|---|---|
| 1 | 5730 | 1.32 |
| 2 | 2865 | 2.64 |
| 3 | 1910 | 3.96 |
| 4 | 1433 | 5.28 |
| 5 | 1146 | 6.60 |
| 6 | 955 | 7.92 |
| 7 | 819 | 9.24 |
| 8 | 717 | 10.6 |
| 9 | 637 | 11.9 |
| 10 | 574 | 13.2 |
| 12 | 478 | 15.8 |
| 14 | 410 | 18.5 |
| 16 | 359 | 21.1 |
| 18 | 320 | 23.8 |
| 20 | 288 | 26.4 |
| 22 | 262 | 29. |
| 24 | 240 | 31.7 |
| 26 | 222 | 34.3 |
| 28 | 207 | 37. |
| 30 | 193 | 39.6 |

The resistance of curves is taken as ½ pound per degree of curve, or equivalent to a grade of 1.32 feet per mile per degree. Dividing 5730 by degrees of curves gives radius in feet—not exact for short curves.

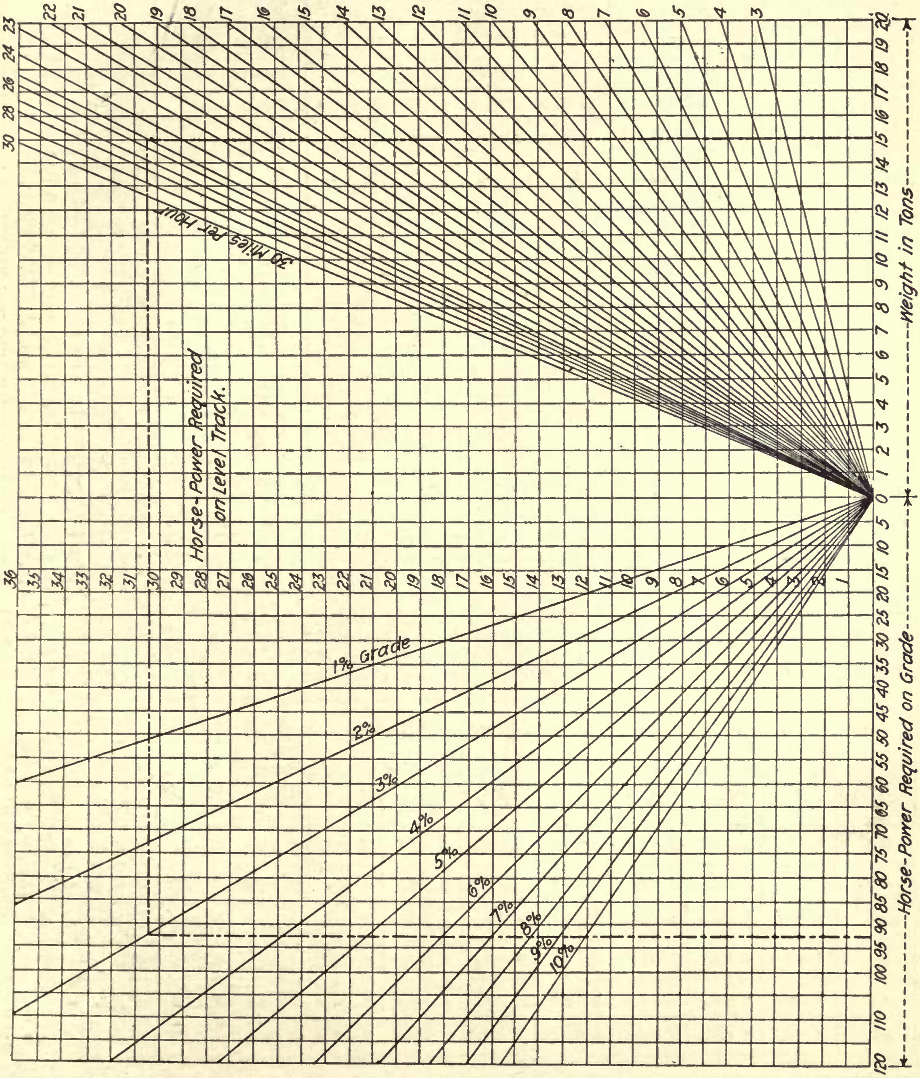
Curves on grades are sometimes eased by widening gage of track $\frac{1}{16}$ inch for each 2½ degrees of curve. Others reduce grade on curves from $\frac{2}{100}$ to $\frac{3}{100}$ of a foot per degree of curve. This equalizes the work of the locomotive.

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 9 (Railway Edition). Explanatory note: Page 38.

## HORSEPOWER REQUIRED FOR MOVING CARS

*Example:— Find Horse-Power required to move a car weighing 15 tons at a speed of 25 miles per hour, both on level track and up a 3 per cent grade.*

*Find weight in tons, 15, on right-hand vertical scale; follow horizontal line from this point to intersection with line for 25 miles per hour speed. From this intersection follow vertical line to scale for Horse-Power required on level track, reading off $30\frac{1}{2}$ H.P. Follow the same vertical line further to intersection with 3 per cent grade line. From the intersection follow the horizontal line to the right-hand vertical scale, finding 93 H.P.*




Contributed by Morris A. Hall, MACHINERY'S Data Sheet No. 110. Explanatory note: Page 38.

## CONSTANTS FOR CALCULATING TRACTIVE FORCE—I

Values of $0.85d^2s$, for Calculating Tractive Power

| Size of Cylinder | Value | Size of Cylinder | Value | Size of Cylinder | Value |
|---|---|---|---|---|---|
| 9" x 14" | 963.9 | 15" x 22" | 4207.5 | 20" x 32" | 10880.0 |
| 9" x 16" | 1101.6 | 15" x 24" | 4590.0 | 20" x 35" | 11560.0 |
| 10" x 14" | 1190.0 | 16" x 20" | 4352.0 | 21" x 24" | 8996.4 |
| 10" x 16" | 1360.0 | 16" x 22" | 4787.2 | 21" x 26" | 9746.1 |
| 10" x 18" | 1530.0 | 16" x 24" | 5222.4 | 21" x 28" | 10495.8 |
| 11" x 14" | 1439.9 | 17" x 20" | 4913.0 | 21" x 30" | 11245.5 |
| 11" x 16" | 1645.6 | 17" x 22" | 5404.3 | 21" x 32" | 11995.2 |
| 11" x 18" | 1851.3 | 17" x 24" | 5895.6 | 22" x 26" | 10696.4 |
| 12" x 16" | 1958.4 | 17" x 26" | 6380.9 | 22" x 28" | 11519.2 |
| 12" x 18" | 2203.2 | 18" x 20" | 5508.0 | 22" x 30" | 12342.0 |
| 12" x 20" | 2448.0 | 18" x 22" | 6058.8 | 22" x 32" | 13164.8 |
| 12" x 22" | 2692.8 | 18" x 24" | 6609.6 | 22" x 34" | 13987.6 |
| 12" x 24" | 2937.6 | 18" x 26" | 7160.4 | 23" x 28" | 12590.2 |
| 13" x 20" | 2873.0 | 19" x 22" | 6737.5 | 23" x 30" | 13489.5 |
| 13" x 22" | 3160.3 | 19" x 24" | 7350.0 | 23" x 32" | 14388.8 |
| 13" x 24" | 3447.6 | 19" x 26" | 7962.5 | 23" x 34" | 15288.1 |
| 14" x 20" | 3332.0 | 20" x 24" | 8160.0 | 24" x 30" | 14688.0 |
| 14" x 22" | 3665.2 | 20" x 26" | 8840.0 | 24" x 32" | 15667.2 |
| 14" x 24" | 3998.4 | 20" x 28" | 9520.0 | 24" x 34" | 16646.4 |
| 15" x 20" | 3825.0 | 20" x 30" | 10200.0 | | |

Note:—The tables were compiled to simplify the use of the well-known formula $T = \frac{0.85 Pd^2s}{D}$. To determine the tractive power of a locomotive, find from the above table the value of $0.85\,d^2s$, in which $d$ is the diameter of the cylinder, $s$ the stroke, and 0.85 the ratio of the M.E.P. (mean effective pressure) to the boiler pressure. Then, in the table of wheel diameters and boiler pressures find a value opposite the wheel diameter (being the given pressure divided by diameter of wheel), and multiply together the two values thus found. The result will be the total tractive power.

Example:— Find the tractive power of a 21 x 26-inch cylinder simple locomotive having driving wheels, 60 inches diameter and boiler pressure, 195 pounds. $0.85\,d^2s = 9746.1$ and the boiler pressure divided by the wheel diameter equals 3.250. Multiplying $9746.1 \times 3.250 = 31,674.8$ pounds, tractive power.

Table of Constants: Driving Wheel Diameters ÷ Boiler Pressures.

| Driving wheel diameter, inches | Boiler pressure, pounds per square inch, gage. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 175 | 180 | 185 | 190 | 195 | 200 | 205 | 210 | 215 | 220 | 225 |
| 48 | 3.646 | 3.750 | 3.854 | 3.959 | 4.053 | 4.157 | 4.261 | 4.365 | 4.469 | 4.573 | 4.678 |
| 49 | 3.571 | 3.673 | 3.776 | 3.878 | 3.980 | 4.082 | 4.184 | 4.286 | 4.388 | 4.490 | 4.592 |
| 50 | 3.500 | 3.600 | 3.700 | 3.800 | 3.900 | 4.000 | 4.100 | 4.200 | 4.300 | 4.400 | 4.500 |
| 51 | 3.431 | 3.529 | 3.627 | 3.725 | 3.824 | 3.922 | 4.020 | 4.118 | 4.216 | 4.314 | 4.412 |
| 52 | 3.365 | 3.462 | 3.558 | 3.654 | 3.750 | 3.846 | 3.942 | 4.038 | 4.135 | 4.231 | 4.327 |
| 53 | 3.302 | 3.396 | 3.491 | 3.585 | 3.679 | 3.774 | 3.868 | 3.962 | 4.057 | 4.151 | 4.245 |

Contributed by L. N. Gillis, MACHINERY'S Data Sheet No. 79. Explanatory note: Page 39.

## CONSTANTS FOR CALCULATING TRACTIVE FORCE—II

| Table of Constants: Driving Wheel Diameters ÷ Boiler Pressures. (Continued) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Driving wheel diameter, inches | Boiler pressure, pounds per square inch, gage. | | | | | | | | | | |
| | 175 | 180 | 185 | 190 | 195 | 200 | 205 | 210 | 215 | 220 | 225 |
| 54 | 3.241 | 3.333 | 3.426 | 3.519 | 3.611 | 3.705 | 3.796 | 3.889 | 3.981 | 4.074 | 4.167 |
| 55 | 3.183 | 3.273 | 3.364 | 3.455 | 3.545 | 3.636 | 3.727 | 3.818 | 3.909 | 4.000 | 4.091 |
| 56 | 3.125 | 3.203 | 3.290 | 3.378 | 3.465 | 3.543 | 3.630 | 3.768 | 3.839 | 3.928 | 4.018 |
| 57 | 3.070 | 3.158 | 3.246 | 3.333 | 3.421 | 3.509 | 3.596 | 3.684 | 3.772 | 3.860 | 3.947 |
| 58 | 3.017 | 3.103 | 3.190 | 3.276 | 3.362 | 3.448 | 3.534 | 3.621 | 3.707 | 3.793 | 3.879 |
| 59 | 2.966 | 3.051 | 3.136 | 3.220 | 3.305 | 3.390 | 3.475 | 3.559 | 3.644 | 3.729 | 3.814 |
| 60 | 2.917 | 3.000 | 3.083 | 3.167 | 3.250 | 3.333 | 3.417 | 3.500 | 3.583 | 3.667 | 3.750 |
| 61 | 2.869 | 2.951 | 3.033 | 3.115 | 3.197 | 3.279 | 3.361 | 3.443 | 3.525 | 3.607 | 3.689 |
| 62 | 2.823 | 2.903 | 2.984 | 3.065 | 3.145 | 3.226 | 3.306 | 3.387 | 3.468 | 3.548 | 3.629 |
| 63 | 2.778 | 2.857 | 2.937 | 3.016 | 3.095 | 3.175 | 3.254 | 3.333 | 3.413 | 3.492 | 3.571 |
| 64 | 2.734 | 2.813 | 2.891 | 2.969 | 3.047 | 3.125 | 3.203 | 3.281 | 3.359 | 3.438 | 3.516 |
| 65 | 2.692 | 2.769 | 2.846 | 2.923 | 3.000 | 3.077 | 3.154 | 3.231 | 3.308 | 3.385 | 3.462 |
| 66 | 2.652 | 2.727 | 2.803 | 2.879 | 2.955 | 3.030 | 3.106 | 3.182 | 3.258 | 3.333 | 3.409 |
| 67 | 2.612 | 2.687 | 2.761 | 2.836 | 2.910 | 2.985 | 3.060 | 3.134 | 3.209 | 3.264 | 3.358 |
| 68 | 2.574 | 2.647 | 2.721 | 2.794 | 2.868 | 2.941 | 3.015 | 3.088 | 3.162 | 3.235 | 3.309 |
| 69 | 2.536 | 2.609 | 2.681 | 2.754 | 2.826 | 2.899 | 2.971 | 3.043 | 3.116 | 3.188 | 3.261 |
| 70 | 2.500 | 2.571 | 2.643 | 2.714 | 2.786 | 2.857 | 2.929 | 3.000 | 3.071 | 3.143 | 3.214 |
| 71 | 2.465 | 2.535 | 2.606 | 2.676 | 2.746 | 2.817 | 2.887 | 2.958 | 3.028 | 3.099 | 3.169 |
| 72 | 2.431 | 2.500 | 2.569 | 2.639 | 2.708 | 2.778 | 2.847 | 2.917 | 2.986 | 3.056 | 3.125 |
| 73 | 2.397 | 2.466 | 2.534 | 2.603 | 2.671 | 2.740 | 2.807 | 2.876 | 2.944 | 3.013 | 3.081 |
| 74 | 2.365 | 2.432 | 2.500 | 2.568 | 2.635 | 2.708 | 2.770 | 2.838 | 2.905 | 2.973 | 3.041 |
| 75 | 2.333 | 2.400 | 2.467 | 2.533 | 2.600 | 2.667 | 2.733 | 2.800 | 2.867 | 2.933 | 3.000 |
| 76 | 2.303 | 2.368 | 2.434 | 2.500 | 2.566 | 2.632 | 2.697 | 2.763 | 2.829 | 2.895 | 2.961 |
| 77 | 2.273 | 2.338 | 2.403 | 2.468 | 2.532 | 2.597 | 2.662 | 2.727 | 2.792 | 2.857 | 2.922 |
| 78 | 2.244 | 2.308 | 2.372 | 2.436 | 2.500 | 2.564 | 2.628 | 2.692 | 2.756 | 2.821 | 2.884 |
| 79 | 2.215 | 2.278 | 2.342 | 2.405 | 2.468 | 2.531 | 2.595 | 2.658 | 2.722 | 2.785 | 2.848 |
| 80 | 2.188 | 2.250 | 2.313 | 2.375 | 2.438 | 2.500 | 2.563 | 2.625 | 2.688 | 2.750 | 2.813 |
| 81 | 2.160 | 2.222 | 2.284 | 2.346 | 2.406 | 2.468 | 2.530 | 2.592 | 2.653 | 2.715 | 2.777 |
| 82 | 2.134 | 2.195 | 2.256 | 2.317 | 2.378 | 2.439 | 2.500 | 2.561 | 2.622 | 2.683 | 2.744 |
| 83 | 2.108 | 2.169 | 2.229 | 2.289 | 2.349 | 2.410 | 2.470 | 2.530 | 2.590 | 2.651 | 2.711 |
| 84 | 2.083 | 2.143 | 2.202 | 2.262 | 2.321 | 2.381 | 2.440 | 2.500 | 2.560 | 2.619 | 2.679 |

Contributed by L. N. Gillis, MACHINERY'S Data Sheet No. 79. Explanatory note: Page 39.

# INERTIA OF TRAINS.—I.

| S Speed Miles per Hour, to be Attained in given Distance. | Tractive Force, Pounds per Ton (2000 Pounds), to Attain Speed S, in Distance D from Starting Point, $= 66.86 \frac{S^2}{D}$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100 Feet. | 250 Feet. | 500 Feet. | 750 Feet. | 1,000 Feet. | 1,500 Feet. | 2,000 Feet. | 3,000 Feet. | 4,000 Feet. | 5,000 Feet. |
| 4 | 10.69 | 4.28 | 2.14 | 1.42 | 1.07 | .713 | .535 | .356 | .267 | .214 |
| 5 | 16.7 | 6.68 | 3.34 | 2.22 | 1.67 | 1.11 | .835 | .556 | .417 | .334 |
| 6 | 24. | 9.6 | 4.8 | 3.2 | 2.4 | 1.6 | 1.2 | .803 | .603 | .481 |
| 8 | 42.7 | 17.1 | 8.54 | 5.7 | 4.27 | 2.84 | 2.13 | 1.42 | 1.07 | .854 |
| 10 | 66.8 | 26.7 | 13.35 | 8.91 | 6.68 | 4.45 | 3.34 | 2.22 | 1.67 | 1.33 |
| 12 | 96. | 38.4 | 19.2 | 12.8 | 9.6 | 6.4 | 4.8 | 3.21 | 2.41 | 1.92 |
| 15 | 150. | 60. | 30. | 20. | 15. | 10. | 7.5 | 5.01 | 3.75 | 3. |
| 20 | 267. | 106. | 53.4 | 35.6 | 26.7 | 17.8 | 13.35 | 8.9 | 6.67 | 5.34 |
| 25 | ...... | 166. | 83.4 | 55.6 | 41.7 | 22.8 | 20.85 | 11.4 | 10.42 | 8.34 |
| 30 | ...... | 240. | 120. | 80.2 | 60.1 | 40.1 | 30. | 20. | 15.04 | 12.03 |
| 35 | ...... | 326. | 163. | 108. | 81.8 | 54.3 | 40.9 | 27.1 | 20.4 | 16.36 |
| 40 | ...... | ...... | 214. | 142. | 107. | 71.3 | 53.5 | 35.6 | 26.7 | 21.4 |
| 45 | ...... | ...... | 270. | 180. | 135. | 90. | 67.6 | 45. | 33.8 | 27. |
| 50 | ...... | ...... | 334. | 222. | 167. | 111. | 83.5 | 55.6 | 41.7 | 33.4 |
| 55 | ...... | ...... | 404. | 269. | 202. | 134. | 101. | 67. | 55.5 | 40.4 |
| 60 | ...... | ..... | ...... | 320. | 240. | 160. | 120. | 80.3 | 60.3 | 48.1 |
| 65 | ...... | ...... | ...... | 376. | 282. | 188. | 141. | 94. | 70.5 | 56.4 |
| 70 | ...... | ...... | ...... | ...... | 327. | 218. | 163. | 109. | 81.5 | 65.4 |

Contributed by Newton Wright, MACHINERY'S Data Sheet No. 21 (Railway Edition). Explanatory note: Page 39.

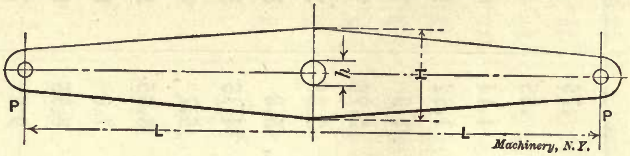
# INERTIA OF TRAINS.—II.

| S Speed Miles per Hour, to be Attained in given Time. | Tractive Force, Pounds per Ton (2000 Pounds) to Attain Speed S, in Time t from Starting = $1.52 \frac{S}{t}$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ½ Minute. | 1 Minute. | 1½ Minute. | 2 Minutes. | 3 Minutes. | 4 Minutes. | 5 Minutes. | 6 Minutes. | 8 Minutes. | 10 Minutes. |
| 4 | 12.16 | 6.08 | 4.08 | 3.04 | 2.02 | 1.52 | 1.21 | 1.01 | .76 | .60 |
| 5 | 15.2 | 7.6 | 5.06 | 3.8 | 2.53 | 1.9 | 1.52 | 1.26 | .95 | .76 |
| 6 | 18.24 | 9.12 | 6.12 | 4.56 | 3.03 | 2.28 | 1.81 | 1.51 | 1.14 | .9 |
| 6 | 24.32 | 12.16 | 8.16 | 6.08 | 4.04 | 3.04 | 2.42 | 2.02 | 1.52 | 1.2 |
| 10 | 30.4 | 15.2 | 10.12 | 7.6 | 5.06 | 3.8 | 3.04 | 2.52 | 1.9 | 1.52 |
| 12 | 36.48 | 18.24 | 12.24 | 9.12 | 6.06 | 4.56 | 3.63 | 3.03 | 2.28 | 1.82 |
| 15 | 45.6 | 22.8 | 15.2 | 10.1 | 7.6 | 5.7 | 4.6 | 3.8 | 2.85 | 2.28 |
| 20 | 60.8 | 30.4 | 20.24 | 15.2 | 10.12 | 7.6 | 6.08 | 5.04 | 3.8 | 3.04 |
| 25 | 76. | 38. | 25.3 | 19. | 12.65 | 9.5 | 7.6 | 6.3 | 4.75 | 3.8 |
| 30 | 91.2 | 45.6 | 30.4 | 20.2 | 15.2 | 11.4 | 9.2 | 7.6 | 5.7 | 4.56 |
| 35 | 106. | 53.2 | 35.4 | 24. | 17.7 | 13.3 | 10.7 | 6.86 | 6.65 | 5.32 |
| 40 | 121. | 60.8 | 40.8 | 30.4 | 20.2 | 15.2 | 12.16 | 10.08 | 7.6 | 6.08 |
| 45 | 136. | 68.4 | 45.8 | 34.2 | 22.7 | 17.1 | 13.68 | 11.34 | 8.55 | 6.84 |
| 50 | 152. | 76. | 50.6 | 38. | 25.3 | 19. | 15.2 | 12.6 | 9.5 | 7.6 |
| 55 | 167. | 83.6 | 55.6 | 41.8 | 27.8 | 20.9 | 16.7 | 13.86 | 10.45 | 8.36 |
| 60 | 182. | 91. | 60. | 40. | 30. | 23. | 18.4 | 15.2 | 11.4 | 9.12 |
| 65 | 197. | 98.6 | 65. | 44. | 32.5 | 25. | 20. | 16.4 | 12.4 | 10. |
| 70 | 212. | 106. | 70. | 47.8 | 35. | 26.9 | 21.28 | 17.66 | 13.35 | 10.7 |

Contributed by Newton Wright, MACHINERY'S Data Sheet No. 21 (Railway Edition). Explanatory note: Page 39.

## TABLE GIVING WIDTH H OF BRAKE LEVERS 3-4 INCH THICK CORRESPONDING TO THE MAXIMUM MOMENT Mx.

$Mx = PL$




$$H = \sqrt{\frac{Mx}{C}} + \frac{1''}{4}$$

$C = 3000$

Allowance made for Hole h under 1 1-4 in. diameter. Stress in outer Fiber varies from 20,000 to 23,000 lbs. per sq. in.

| Mx | H | Mx | H | Mx | H |
|---|---|---|---|---|---|
| | Inches. | | Inches. | | Inches |
| 6000 | $1\frac{3}{4}$ | 60000 | $4\frac{3}{4}$ | 150000 | $7\frac{1}{4}$ |
| 7500 | $1\frac{7}{8}$ | 63000 | $4\frac{7}{8}$ | 156000 | $7\frac{1}{2}$ |
| 9000 | 2 | 66000 | $4\frac{7}{8}$ | 162000 | $7\frac{5}{8}$ |
| 10500 | $2\frac{1}{8}$ | 69000 | 5 | 168000 | $7\frac{3}{4}$ |
| 12000 | $2\frac{1}{4}$ | 72000 | $5\frac{1}{8}$ | 174000 | $7\frac{7}{8}$ |
| 13500 | $2\frac{3}{8}$ | 75000 | $5\frac{1}{4}$ | 180000 | 8 |
| 15000 | $2\frac{1}{2}$ | 78000 | $5\frac{3}{8}$ | 186000 | $8\frac{1}{8}$ |
| 16500 | $2\frac{5}{8}$ | 81000 | $5\frac{3}{8}$ | 192000 | $8\frac{1}{4}$ |
| 18000 | $2\frac{3}{4}$ | 84000 | $5\frac{1}{2}$ | 198000 | $8\frac{3}{8}$ |
| 19500 | $2\frac{3}{4}$ | 87000 | $5\frac{5}{8}$ | 204000 | $8\frac{1}{2}$ |
| 21000 | $2\frac{7}{8}$ | 90000 | $5\frac{3}{4}$ | 210000 | $8\frac{5}{8}$ |
| 22500 | 3 | 93000 | $5\frac{7}{8}$ | 216000 | $8\frac{3}{4}$ |
| 24000 | $3\frac{1}{8}$ | 96000 | $5\frac{7}{8}$ | 222000 | $8\frac{7}{8}$ |
| 25500 | $3\frac{1}{8}$ | 99000 | 6 | 228000 | 9 |
| 27000 | $3\frac{1}{4}$ | 102000 | $6\frac{1}{8}$ | 234000 | $9\frac{1}{8}$ |
| 28500 | $3\frac{1}{2}$ | 105000 | $6\frac{1}{4}$ | 240000 | $9\frac{1}{4}$ |
| 30000 | $3\frac{1}{2}$ | 108000 | $6\frac{1}{4}$ | 246000 | $9\frac{1}{4}$ |
| 33000 | $3\frac{5}{8}$ | 111000 | $6\frac{3}{8}$ | 252000 | $9\frac{3}{8}$ |
| 36000 | $3\frac{3}{4}$ | 114000 | $6\frac{3}{8}$ | 258000 | $9\frac{1}{2}$ |
| 39000 | $3\frac{7}{8}$ | 117000 | $6\frac{1}{2}$ | 264000 | $9\frac{5}{8}$ |
| 42000 | 4 | 120000 | $6\frac{5}{8}$ | 270000 | $9\frac{3}{4}$ |
| 45000 | $4\frac{1}{8}$ | 123000 | $6\frac{3}{4}$ | 276000 | $9\frac{7}{8}$ |
| 48000 | $4\frac{1}{4}$ | 126000 | $6\frac{3}{4}$ | 282000 | 10 |
| 51000 | $4\frac{3}{8}$ | 132000 | $6\frac{7}{8}$ | 288000 | $10\frac{1}{8}$ |
| 54000 | $4\frac{1}{2}$ | 138000 | 7 | 294000 | $10\frac{1}{4}$ |
| 57000 | $4\frac{5}{8}$ | 144000 | $7\frac{1}{8}$ | 300000 | $10\frac{1}{4}$ |

## TABLE GIVING WIDTH H OF BRAKE LEVERS 1 INCH THICK CORRESPONDING TO THE MAXIMUM MOMENT Mx. C = 4000.

Allowance made for Hole h under 1 1-2 in. diameter. Stress in outer Fiber varies from 20,000 to 23,000 lbs. per sq. in.

| | | | | | |
|---|---|---|---|---|---|
| 12000 | 2 | 24000 | $2\frac{3}{4}$ | 36000 | $3\frac{1}{4}$ |
| 14000 | $2\frac{1}{8}$ | 26000 | $2\frac{3}{4}$ | 38000 | $3\frac{3}{8}$ |
| 16000 | $2\frac{1}{4}$ | 28000 | $2\frac{7}{8}$ | 40000 | $3\frac{1}{2}$ |
| 18000 | $2\frac{3}{8}$ | 30000 | 3 | 44000 | $3\frac{5}{8}$ |
| 20000 | $2\frac{1}{2}$ | 32000 | $3\frac{1}{8}$ | 48000 | $3\frac{3}{4}$ |
| 22000 | $2\frac{5}{8}$ | 34000 | $3\frac{1}{4}$ | 52000 | $3\frac{7}{8}$ |

Contributed by E. G. Chenoweth, MACHINERY'S Data Sheet No. 33 (Railway Edition). Explanatory note: Page 39.

## TABLE GIVING WIDTH H OF BRAKE LEVERS 1 INCH THICK CORRESPONDING TO THE MAXIMUM MOMENT M x. (Continued.)

**Allowance made for hole h under 1 1-2 in. diameter. Stress in outer Fiber varies from 20,000 to 23,000 lbs. per sq. in.**

| M x | H | M x | H | M x | H |
|---|---|---|---|---|---|
| | inches. | | Inches. | | Inches. |
| 56000 | 4 | 136000 | $6\frac{1}{8}$ | 224000 | $7\frac{3}{4}$ |
| 60000 | $4\frac{1}{8}$ | 140000 | $6\frac{1}{4}$ | 232000 | $7\frac{7}{8}$ |
| 64000 | $4\frac{1}{4}$ | 144000 | $6\frac{1}{4}$ | 240000 | 8 |
| 68000 | $4\frac{3}{8}$ | 148000 | $6\frac{3}{8}$ | 248000 | $8\frac{1}{8}$ |
| 72000 | $4\frac{1}{2}$ | 152000 | $6\frac{3}{8}$ | 256000 | $8\frac{1}{4}$ |
| 76000 | $4\frac{5}{8}$ | 156000 | $6\frac{1}{2}$ | 264000 | $8\frac{3}{8}$ |
| 80000 | $4\frac{3}{4}$ | 160000 | $6\frac{5}{8}$ | 272000 | $8\frac{1}{2}$ |
| 84000 | $4\frac{7}{8}$ | 164000 | $6\frac{3}{4}$ | 280000 | $8\frac{5}{8}$ |
| 88000 | 5 | 168000 | $6\frac{3}{4}$ | 288000 | $8\frac{3}{4}$ |
| 92000 | $5\frac{1}{8}$ | 172000 | $6\frac{7}{8}$ | 296000 | $8\frac{7}{8}$ |
| 96000 | $5\frac{1}{4}$ | 176000 | $6\frac{7}{8}$ | 304000 | 9 |
| 100000 | $5\frac{1}{4}$ | 180000 | 7 | 312000 | $9\frac{1}{8}$ |
| 104000 | $5\frac{3}{8}$ | 184000 | 7 | 320000 | $9\frac{1}{4}$ |
| 108000 | $5\frac{1}{2}$ | 188000 | $7\frac{1}{8}$ | 328000 | $9\frac{3}{8}$ |
| 112000 | $5\frac{5}{8}$ | 192000 | $7\frac{1}{4}$ | 336000 | $9\frac{1}{2}$ |
| 116000 | $5\frac{3}{4}$ | 196000 | $7\frac{1}{4}$ | 344000 | $9\frac{5}{8}$ |
| 120000 | $5\frac{3}{4}$ | 200000 | $7\frac{3}{8}$ | 352000 | $9\frac{3}{4}$ |
| 124000 | $5\frac{7}{8}$ | 208000 | $7\frac{1}{2}$ | 360000 | $9\frac{7}{8}$ |
| 128000 | $5\frac{7}{8}$ | 216000 | $7\frac{5}{8}$ | 368000 | 10 |
| 132000 | 6 | ...... | .. | ...... | ... |

## TABLE GIVING WIDTH H OF BRAKE LEVERS 1 1-4 INCH THICK CORRESPONDING TO THE MAXIMUM MOMENT M x. C = 5000.

**Allowance made for Hole h under 1 1-2 in. diameter. Stress in outer Fiber varies from 20,000 to 23,000 lbs. per sq. in.**

| | | | | | |
|---|---|---|---|---|---|
| 50000 | $3\frac{1}{2}$ | 140000 | $5\frac{1}{2}$ | 260000 | $7\frac{1}{2}$ |
| 55000 | $3\frac{5}{8}$ | 145000 | $5\frac{5}{8}$ | 270000 | $7\frac{5}{8}$ |
| 60000 | $3\frac{3}{4}$ | 150000 | $5\frac{3}{4}$ | 280000 | $7\frac{3}{4}$ |
| 65000 | $3\frac{7}{8}$ | 155000 | $5\frac{3}{4}$ | 290000 | $7\frac{7}{8}$ |
| 70000 | 4 | 160000 | $5\frac{7}{8}$ | 300000 | 8 |
| 75000 | $4\frac{1}{8}$ | 165000 | 6 | 310000 | $8\frac{1}{8}$ |
| 80000 | $4\frac{1}{4}$ | 170000 | $6\frac{1}{8}$ | 320000 | $8\frac{1}{4}$ |
| 85000 | $4\frac{3}{8}$ | 175000 | $6\frac{1}{4}$ | 330000 | $8\frac{3}{8}$ |
| 90000 | $4\frac{1}{2}$ | 180000 | $6\frac{1}{4}$ | 340000 | $8\frac{1}{2}$ |
| 95000 | $4\frac{5}{8}$ | 185000 | $6\frac{3}{8}$ | 350000 | $8\frac{5}{8}$ |
| 100000 | $4\frac{3}{4}$ | 190000 | $6\frac{3}{8}$ | 360000 | $8\frac{3}{4}$ |
| 105000 | $4\frac{3}{4}$ | 195000 | $6\frac{1}{2}$ | 370000 | $8\frac{7}{8}$ |
| 110000 | $4\frac{7}{8}$ | 200000 | $6\frac{5}{8}$ | 380000 | 9 |
| 115000 | 5 | 210000 | $6\frac{3}{4}$ | 390000 | $9\frac{1}{8}$ |
| 120000 | $5\frac{1}{8}$ | 220000 | $6\frac{7}{8}$ | 400000 | $9\frac{1}{4}$ |
| 125000 | $5\frac{1}{4}$ | 230000 | 7 | 410000 | $9\frac{3}{8}$ |
| 130000 | $5\frac{3}{8}$ | 240000 | $7\frac{1}{4}$ | 420000 | $9\frac{3}{8}$ |
| 135000 | $5\frac{1}{2}$ | 250000 | $7\frac{3}{8}$ | 430000 | $9\frac{1}{2}$ |

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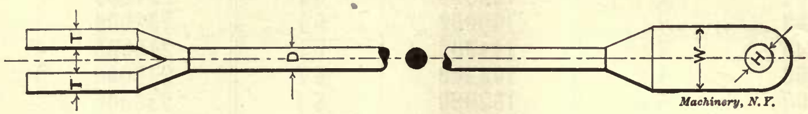
# PROPORTIONS FOR BRAKE RODS.

**Based on M. C. B. Recommended Practice.**

Fiber Stress for Diameter D not to exceed 15,000 pounds per square inch.
" " " Width W " " " 10,000 " " " "
Shear on Pins H not to exceed 10,000 pounds per square inch.




| Diam. of Rod D. | Area of Section D | Strength of Rod, Fiber Stress 15,000 pounds per square inch. | Sectional Area of Jaw through Pin-Hole; Fiber Stress 10,000 lbs. per square inch. | Diameter of Pin Hole H for Various Diameters of D. | Square of Diameter of Pin-hole H. | Width W for Various Thicknesses of T. (Given to the Nearest ⅛".) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ⅝" | ¾" | ⅞" | 1" | 1⅛ | 1¼" |
| ⅞" | .6013 | 9020 | .9020 | 1⅛" | 1.2656 | 1⅞" | 1¾" | 1⅝" | 1⅝" | .... | .... |
| 1" | .7854 | 11781 | 1.1781 | 1⅛" | 1.2656 | 2" | 2" | 1⅞" | 1¾" | .... | .... |
| 1⅛" | .9940 | 14910 | 1.4910 | 1⅛" | 1.2656 | 2⅜" | 2⅛" | 2" | 2" | 1¾" | .... |
| 1¼" | 1.2272 | 18408 | 1.8408 | 1⅛" | 1.2656 | 2⅝" | 2⅜" | 2⅛" | 2⅛" | 2" | .... |
| 1⅜" | 1.4849 | 22274 | 2.2274 | 1¼" | 1.5625 | 3⅛" | 2¾" | 2½" | 2⅜" | 2¼" | 2⅛" |
| 1½" | 1.7671 | 26507 | 2.6507 | 1⅜" | 1.8906 | 3½" | 3⅛" | 2⅞" | 2¾" | 2½" | 2½" |
| 1⅝" | 2.0739 | 31109 | 3.1109 | 1½" | 2.2500 | 4" | 3⅝" | 3¼" | 3" | 2⅞" | 2¾" |
| 1¾" | 2.4053 | 36080 | 3.6080 | 1⅝" | 2.6406 | 4½" | 4" | 3⅝" | 3½" | 3¼" | 3⅛" |
| 1⅞" | 2.7612 | 41418 | 4.1418 | 1⅝" | 2.6406 | .... | 4⅜" | 4" | 3¾" | 3½" | 3¼" |
| 2" | 3.1416 | 47124 | 4.7124 | 1¾" | 3.0625 | .... | 5" | 4½" | 4⅛" | 3⅞" | 3⅝" |
| 2⅛" | 3.5466 | 53199 | 5.3199 | 1⅞" | 3.5156 | .... | .... | 5" | 4½" | 4¼" | 4" |
| 2¼" | 3.9761 | 59642 | 5.9642 | 2" | 4.0000 | .... | .... | 5½" | 5" | 4⅝" | 4⅜" |
| 2⅜" | 4.4301 | 66452 | 6.6452 | 2⅛" | 4.5156 | .... | .... | .... | 5½" | 5" | 4¾" |
| 2½" | 4.9087 | 73631 | 7.3631 | 2¼" | 5.0625 | .... | .... | .... | 6" | 5½" | 5¼" |
| 2⅝" | 5.4119 | 81179 | 8.1179 | 2⅜" | 5.6406 | .... | .... | .... | 6½" | 6" | 5⅝" |
| 2¾" | 5.9396 | 89094 | 8.9094 | 2½" | 6.2500 | .... | .... | .... | .... | 6½" | 6⅛" |
| 2⅞" | 6.4918 | 97377 | 9.7377 | 2½" | 6.2500 | .... | .... | .... | .... | .... | 6½" |
| 3" | 7.0686 | 106029 | 10.6029 | 2⅝" | 6.8906 | .... | .... | .... | .... | .... | 6⅞" |
| 3⅛" | 7.6699 | 115049 | 11.5049 | 2¾" | 7.5625 | .... | .... | .... | .... | .... | 7⅜" |

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## ANGLES OF DEFLECTION OF CENTER LINE OF TRUCK FROM CENTER LINE OF CAR ON CURVES.

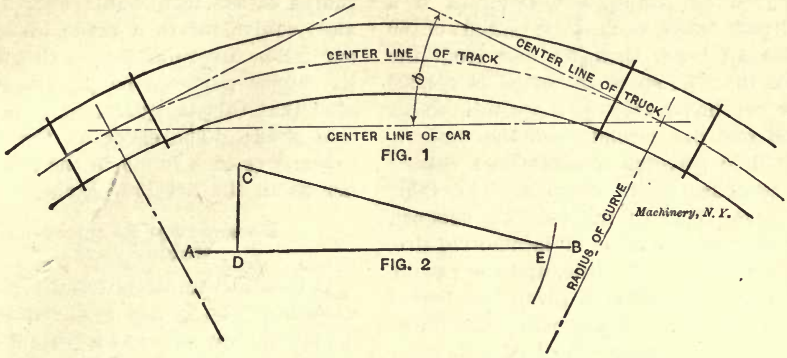

FIG. 1

FIG. 2

Put $\sin \phi = \frac{\frac{1}{2} L}{R}$, in which $L$ = length center to center of bolsters and $R$ = radius of curve, in feet, and the angle $\phi$ can be laid out without using protractor. Erect to scale a perpendicular $CD = \frac{1}{2} L$ on base line $AB$, Fig. 2. Then with $C$ as a center, and radius $R$ = radius of curve, to same scale, strike an arc intersecting $AB$ at $E$. Angle $CED$ is the angle required.

### RADIUS OF CURVE IN FEET.

| Center to Center of Bolsters, in feet. | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 5° 45′ | 4° 47′ | 4° 6′ | .3° 38′ | 3° 11′ | 2° 52′ | 2° 36′ | 2° 23′ | 2° 12′ | 2° 3′ | 1° 54′ | 1° 50′ | 1° 41′ |
| 11 | 6 19 | 5 11 | 4 30 | 3 57 | 3 30 | 3 9 | 2 52 | 2 38 | 2 28 | 2 15 | 2 6 | 1 58 | 1 51 |
| 12 | 6 54 | 5 45 | 4 55 | 4 19 | 3 47 | 3 27 | 3 7 | 2 52 | 2 39 | 2 27 | 2 18 | 2 9 | 2 1 |
| 13 | 7 28 | 6 13 | 5 20 | 4 40 | 4 9 | 3 44 | 3 26 | 3 6 | 2 52 | 2 40 | 2 29 | 2 20 | 2 12 |
| 14 | 8 3 | 6 30 | 5 45 | 5 1 | 4 28 | 4 1 | 3 39 | 3 21 | 3 5 | 2 52 | 2 40 | 2 31 | 2 22 |
| 15 | 8 38 | 7 11 | 6 9 | 5 23 | 4 47 | 4 19 | 3 54 | 3 35 | 3 18 | 3 4 | 2 52 | 2 41 | 2 32 |
| 16 | 9 13 | 7 39 | 6 34 | 5 45 | 5 6 | 4 36 | 4 10 | 3 49 | 3 32 | 3 17 | 3 3 | 2 52 | 2 41 |
| 17 | 9 47 | 8 9 | 6 59 | 6 6 | 5 25 | 4 53 | 4 26 | 4 4 | 3 45 | 3 29 | 3 15 | 3 3 | 2 52 |
| 18 | 10 22 | 8 38 | 7 23 | 6 28 | 5 45 | 5 10 | 4 42 | 4 18 | 3 58 | 3 41 | 3 27 | 3 13 | 3 2 |
| 19 | 10 57 | 9 7 | 7 43 | 6 49 | 6 4 | 5 27 | 4 57 | 4 32 | 4 11 | 3 53 | 3 38 | 3 24 | 3 12 |
| 20 | 11 32 | 9 36 | 8 13 | 7 11 | 6 23 | 5 45 | 5 13 | 4 47 | 4 25 | 4 5 | 3 49 | 3 35 | 3 22 |
| 21 | 11 36 | 10 5 | 8 38 | 7 33 | 6 42 | 6 2 | 5 29 | 5 1 | 4 38 | 4 18 | 4 1 | 3 46 | 3 32 |
| 22 | 12 43 | 10 34 | 9 3 | 7 54 | 7 1 | 6 19 | 5 45 | 5 15 | 4 51 | 4 30 | 4 12 | 3 57 | 3 43 |
| 23 | 13 18 | 11 3 | 9 27 | 8 16 | 7 20 | 6 36 | 6 0 | 5 30 | 5 4 | 4 43 | 4 24 | 4 7 | 3 53 |
| 24 | 13 53 | 11 32 | 9 52 | 8 38 | 7 40 | 6 54 | 6 16 | 5 45 | 5 18 | 4 55 | 4 35 | 4 18 | 4 3 |
| 25 | 14 29 | 12 1 | 10 17 | 8 59 | 7 59 | 7 11 | 6 32 | 5 59 | 5 31 | 5 7 | 4 47 | 4 29 | 4 13 |
| 26 | 15 4 | 12 31 | 10 42 | 9 21 | 8 18 | 7 28 | 6 47 | 6 13 | 5 45 | 5 20 | 4 58 | 4 40 | 4 23 |
| 27 | 15 40 | 13 0 | 11 7 | 9 43 | 8 38 | 7 46 | 7 3 | 6 28 | 5 58 | 5 32 | 5 10 | 4 50 | 4 33 |
| 28 | 16 16 | 13 30 | 11 32 | 10 5 | 8 57 | 8 3 | 7 19 | 6 42 | 6 11 | 5 45 | 5 21 | 5 1 | 4 43 |
| 29 | 16 52 | 13 59 | 11 57 | 10 27 | 9 16 | 8 20 | 7 35 | 6 56 | 6 24 | 5 51 | 5 33 | 5 12 | 4 53 |
| 30 | 17 28 | 14 29 | 12 22 | 10 49 | 9 36 | 8 38 | 7 50 | 7 11 | 6 37 | 6 9 | 5 45 | 5 23 | 5 4 |
| 31 | 18 4 | 14 58 | 12 48 | 11 10 | 9 55 | 8 55 | 8 6 | 7 25 | 6 51 | 6 21 | 5 56 | 5 33 | 5 14 |
| 32 | 18 40 | 15 28 | 13 13 | 11 32 | 10 14 | 9 13 | 8 22 | 7 40 | 7 4 | 6 34 | 6 7 | 5 45 | 5 24 |
| 33 | 19 17 | 15 58 | 13 38 | 11 54 | 10 42 | 9 30 | 8 38 | 7 54 | 7 18 | 6 46 | 6 19 | 5 55 | 5 34 |
| 34 | 19 53 | 16 28 | 14 4 | 12 16 | 10 53 | 9 47 | 8 53 | 8 9 | 7 31 | 6 59 | 6 20 | 6 6 | 5 45 |
| 35 | 20 29 | 16 57 | 14 29 | 12 38 | 11 13 | 10 5 | 9 9 | 8 23 | 7 31 | 7 11 | 6 42 | 6 17 | 5 55 |
| 36 | 21 6 | 17 28 | 14 54 | 13 0 | 11 32 | 10 23 | 9 25 | 8 38 | 7 57 | 7 23 | 6 54 | 6 28 | 6 5 |

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of trains. In the table on page 26 a comparison is made between speed in miles per hour, feet per hour, feet per minute, feet per second, and the time required per mile. For example, if a railroad train runs at a speed of 50 miles an hour, then we find from the table that the space traversed is 264,000 feet per hour, 4400 feet per minute, or 73.33 feet per second; and the time required to traverse one mile is 1 minute 12 seconds, or 72 seconds. The table on page 27 gives the relation between the diameter of a car or locomotive tire, the revolutions per mile, and the revolutions per minute at a given number of miles per hour. Assume that the diameter of the driving wheel of a locomotive is 56 inches. Then we find from the table that its circumference is 14.66 feet, and that it makes 360.2 revolutions per mile. If the locomotive runs at a speed of 40 miles per hour, it will be seen that the driving wheel will make 240.12 revolutions per minute.

### Grades and their Effect on Hauling Capacity

On page 28 a table is given of the relation between grades and the hauling capacity of locomotives. From the table it will be seen that a three per cent grade, for example, is equivalent to a rise of 158.4 feet per mile, or a rise of 1 foot in 33.33 feet. At a speed of 10 miles per hour, the resistance per each ton hauled is equivalent to 69.9 pounds. Assuming that the tractive power of a locomotive is one-fourth of the weight on the drivers, the number of tons hauled on a three per cent grade, for each 1000 pounds on the drivers, would be 3.8. Assuming that the tractive power is only one-fifth of the weight on the drivers, this giving a more conservative calculation, only three tons can be hauled for each 1000 pounds on the drivers.

In the lower part on page 28 a table is given where curves are reduced to equivalent grade, so as to make it possible to use the table in the upper part of the page to find the hauling capacity of locomotives on curves. For example, a 20-degree curve, or a curve having a radius of 288 feet, would offer a resistance equivalent to a grade of 26.4 feet per mile. By referring to the table in the upper part of the page it will be seen that this is equivalent to a 0.5 per cent grade. The effect on the hauling capacity is then found in the same manner as in the previous example.

### Horsepower Required for Moving Cars

It is a rather complicated problem to determine the power required to move a railroad car of known weight at any known speed over a level track, or up a known grade. A diagram, or graphical chart, however, can be prepared, from which the power required may be obtained practically at a glance if the quantities speed, weight and grade be known. Such a diagram is presented on page 29. Suppose, for an example, that the car weighs 15 tons, or 30,000 pounds, and assume further that we wish to move this car at a speed of 25 miles per hour over a level track. Find first on the right-hand vertical scale the point marked 15 tons (the weight of the car), and follow the horizontal line from this point to the intersection with the oblique line marked 25 miles per hour and from this intersection follow a vertical line downward intersecting the horsepower scale for level track at 30½ H.P. Suppose that the car must also climb a grade of 3 per cent somewhere on the line. In order to find the horsepower required for this, follow the same vertical line, already found, until it intersects the oblique grade line marked 3 per cent grade, and then follow the horizontal line from this intersection point to the right-hand vertical scale, where we find the required power for climbing the grade to be 93 H.P. As will be seen, the diagram can be used for cars weighing up to 20 tons, for

speeds from 3 to 30 miles per hour, and for grades from 1 to 10 per cent.

### Constants for Calculating Tractive Force

On pages 30 and 31 are given tables containing constants for the calculation of the tractive force of locomotives. The note beneath the upper table on page 30 gives the necessary explanation of the tables and illustrates their use by means of an example.

### Inertia of Trains

On pages 32 and 33 are given two tables of the inertia of trains. These tables give the tractive force, in pounds, required for each ton hauled to obtain a speed of $S$ miles per hour, in a certain distance in feet. As an example, find the tractive force required per each ton of load hauled to attain a speed of 10 miles per hour in a distance of 1000 feet. By referring to the table on page 32, we find that the tractive force required is 6.68 pounds per ton.

The table on page 33 gives the tractive force, in pounds, which is required per ton of load for attaining a speed of $S$ miles per hour in a specified length of time. As an example, find the tractive force required for attaining a speed of 30 miles per hour in three minutes. By referring to the table on page 33 we find that a tractive force of 15.2 pounds per ton hauled is required.

### Brake Levers

On pages 34 and 35 is given a table of the width of brake levers in which the maximum fiber stress does not exceed the recommended figure of 23,000 pounds per square inch adopted by the Master Car Builders' Association.

The formula

$$H = \sqrt{\frac{Mx}{C}} + 1/4 \text{ inch}$$

is derived as follows:

Let $Mx$ = maximum moment,
$S$ = stress per square inch,
$I$ = moment of inertia,
$E$ = maximum distance from the center of gravity to outer fiber $= H/2$,
$H$ = width of lever,
$b$ = thickness of lever,
$h$ = diameter of hole,
$C$ = constant which varies with $b$,
$P$ = pull at end of lever,
$L$ = lever arm.

Then for a lever 1 inch thick:

$$PL = Mx = \frac{S\,I}{E} = \frac{24{,}000\, b H^3}{12\, E} = \frac{2000\, b H^3}{E} = \frac{2000\, H^3}{H/2} = 4000\, H^2$$

Hence, $H^2 = \frac{Mx}{4000}$, and $H = \sqrt{\frac{Mx}{4000}}$.

For other levers the formulas are derived in the same way, the value of $b$ only being changed. By taking 24,000 pounds for the value of $S$ and then adding 1/4 inch to the width, the maximum allowable stresses vary from 20,000 to 23,000 pounds per square inch, as given in the tables. For a ¾-inch thick brake lever, $C = 3000$ instead of 4000.

On page 36 are given proportions for brake rods according to the Master Car Builders' recommendations.

### Deflection of Truck from Center of Car on Curves

On page 37 are given angles of deflection of the center line of the truck from the center line of the car on curves, for various radii. For example, if the center to center distance of the bolsters is 25 feet, and the radius of the curve 150 feet, then, according to the table, the angle of deflection of the center line of the truck from the center line of the car equals 4 degrees 47 minutes. These angles of deflection must be taken into consideration by the designer when laying out brake rigging connections, otherwise interference of the brake rods with the wheels is likely to develop on sharp curves.

No. 16. **Machine Tool Drives.**—Speeds and Feeds of Machine Tools; Geared or Single Pulley Drives; Drives for High Speed Cutting Tools.

No. 17. **Strength of Cylinders**—Formulas, Charts, and Diagrams.

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No. 42. **Jigs and Fixtures,** Part II.—Open and Closed Drill Jigs.

No. 43. **Jigs and Fixtures,** Part III.—Boring and Milling Fixtures.

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No. 45. **Drop Forging.**—Lay-out oi Plant; Methods of Drop Forging; Dies.

No. 46. **Hardening and Tempering.**—Hardening Plants; Treating High-Speed Steel; Hardening Gages; Hardening Kinks.

No. 47. **Electric Overhead Cranes.**—Design and Calculation.

No. 48. **Files and Filing.**—Types of Files; Using and Making Files.

No. 49. **Girders for Electric Overhead Cranes.**

No. 50. **Principles and Practice of Assembling Machine Tools,** Part I.

No. 51. **Principles and Practice of Assembling Machine Tools,** Part II.

No. 52. **Advanced Shop Arithmetic for the Machinist.**

No. 53. **Use of Logarithms and Logarithmic Tables.**

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No. 62. **Hardness and Durability Testing of Metals.**

No. 63. **Heat Treatment of Steel.**—Hardening, Tempering and Case-Hardening.

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No. 65. **Formulas and Constants for Gas Engine Design.**



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